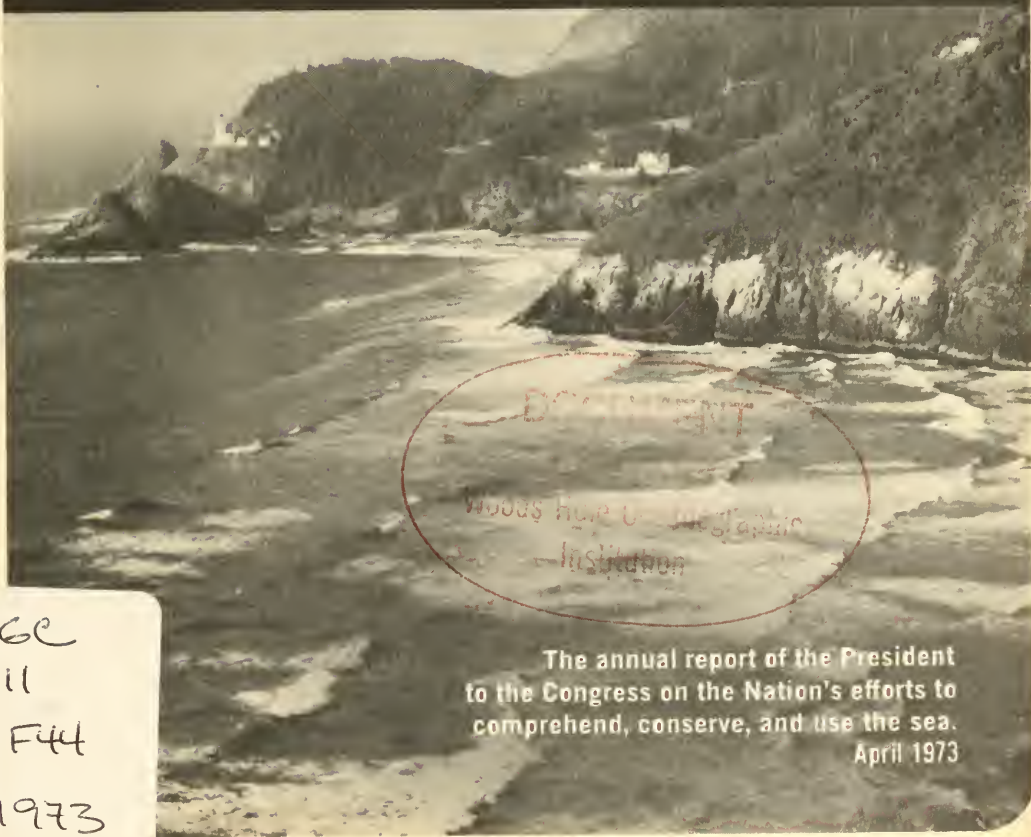


Apr 1972

THE FEDERAL OCEAN PROGRAM



The annual report of the President
to the Congress on the Nation's efforts to
comprehend, conserve, and use the sea.
April 1973

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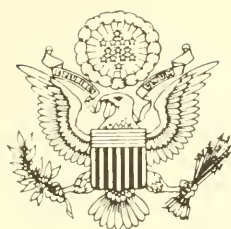
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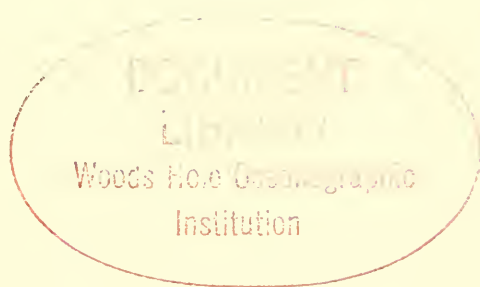
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THE FEDERAL OCEAN PROGRAM



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LETTER OF TRANSMITTAL

TO THE CONGRESS OF THE UNITED STATES:

The past decade has been a productive period in our Nation's effort to better understand and utilize our marine resources. The early 1960's saw the establishment of a firm foundation for our Nation's oceanographic research programs. Building on this research base in the late 60's and early 70's, we began formulating policies and carrying out plans to derive practical benefits from our ocean activities. New marine-related institutions were developed, the importance of marine sciences to the activities of existing institutions was recognized, and their efforts were expanded. While recognizing the ongoing importance of basic research, I believe that this emphasis on practical benefits must also be carried forward in the years ahead.

Ocean Industries

We have been particularly concerned of late with the challenge of relieving our dependence on marine imports and at the same time, providing new products and services for export. Our fishing industry has been a special focus of concern. At present, we import approximately 70 percent of our fish products, in spite of the fact that some of the world's most fertile fisheries lie directly off our coasts. These imports contribute a billion dollars to our foreign trade deficit. To help protect our domestic fishing industry, I have recommended legislation which would permit U.S. regulation of foreign fishing off our coasts to the fullest extent authorized by international agreements and would permit Federal regulation of domestic fisheries in the U.S. fisheries zone and in the high seas beyond that zone.

Of the non-living or mineral resources of the seabed, petroleum from our continental shelves will be the most important to the Nation for some years to come. I have directed the Secretary of the Interior to continue to accelerate the leasing of Outer Continental Shelf lands for oil and gas production, to a level triple the present annual acreage rate by 1979, as long as such development can proceed with adequate protection of the environment and under conditions consistent with my Oceans Policy statement of May 1970.

We are also seeking agreement with other nations on a suitable means for developing mineral resources beyond the limits of national jurisdiction.

Managing our Marine Resources

Our efforts to improve the means by which we extract resources from the sea must be accompanied by efforts to ensure that those resources are managed properly to protect their continued abundance. In America, as in other nations, there is a deepening concern for the marine environment and the welfare of its associated plant and animal life. There is also a growing worldwide recognition that the welfare of the ocean resources is of international concern. This concern has been manifested in the establishment of the United Nations Environment Program and Fund following the Conference on the Human Environment at Stockholm, and in the recent Convention on International Trade in Endangered Wild Species of Fauna and Flora. The Marine Mammals Act of 1972, which will help in the preservation of porpoises, seals, whales and other mammals which inhabit the seas and shores, is another significant step in this effort. So is my proposed Endangered Species Conservation Act, which would permit protective measures to be undertaken before a species is so depleted that its recovery is difficult or impossible.

The need for proper management of our coastal areas is inextricably linked with the need for proper management of our marine resources. Much of our population is concentrated on the relatively narrow band of our national coastal zone. The problems of urban development and land transportation within this zone, as well as the impact of ocean vessels of mammoth tonnage, demand serious consideration of our entire coastal transportation complex—including deepwater ports and off-shore terminals. Recently proposed legislation for the licensing of deepwater ports is another key element in our effort to anticipate and resolve this problem.

I believe that coastal zone management must be part of a program for the proper management of all our national lands. For this reason, my legislative program for this year included again my recommendation for a major National Land Use Policy Act, a bill which would place special emphasis on the problems of our coastal zone.

I have further requested that the Senate give its consent to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, adopted in November 1972 by the United States and 91 other nations. I have proposed amendments to our ocean dumping legislation fully to implement the Convention and I am proposing legislation to carry out other international agreements related to pollution control under the auspices of the Intergovernmental Maritime Consultative Organization.

Marine Advisory Services

To support Federal marine programs and to assist in their application for the benefit of the American public, a marine advisory service has been established to serve as a two-way communications link with the public. Field agents of this advisory service—"county agents in hip boots"—will help bring to the Nation an awareness of our ocean heritage and its potential for satisfying many of our economic and social needs.

International Cooperation

Problems of the marine environment have a unique global dimension. As we continue our efforts in the marine areas that I have highlighted, we shall also work to improve the performance of these functions within the international community. We are already making headway, for example, in advancing the International Decade of Ocean Exploration, the International Field Year of the Great Lakes, and the Integrated Global Ocean Station System of the Intergovernmental Oceanographic Commission and the World Meteorological Organization.

We have also established special agreements for cooperative marine activities with a number of nations, including Canada, France, Japan, and the USSR. In addition, we shall take whatever efforts are required to fulfill those commitments made at the Stockholm Conference on the Human Environment, the meetings of the International Whaling Commission, and the significant deliberations of numerous other organizations dedicated to fisheries and the marine environment. We shall also continue to work with developing nations, helping them to realize more fully the benefits available to them from the oceans and generating the climate necessary to assure freedom of research at sea for all nations.

Finally, we must seek ways to insure that the oceans remain an avenue of peaceful cooperation rather than an arena of tension-filled confrontation. Our efforts in the Law of the Sea deliberations, now beginning, will be devoted to this goal.

Conclusion

America is a seagoing nation with great dependence on the oceans that surround it. We can take pride in our past leadership and our accomplishments in marine science and engineering. I am determined that our future Federal marine effort will continue that leadership to the benefit of our Nation and all mankind.

A handwritten signature in dark ink, reading "Richard Nixon". The signature is fluid and cursive, with a long, sweeping underline that extends to the right.

PREFACE

A Report to the President From the Office of Science and Technology, April 1973

THIS REPORT TO THE PRESIDENT ON THE FEDERAL OCEAN PROGRAM is prepared in accordance with Public Law 89-454, the Marine Resources and Engineering Development Act of 1966, which states that the President shall transmit to the Congress an annual report including: (a) A comprehensive description of the activities and the accomplishments of all the agencies and departments of the United States in the field of marine sciences during the preceeding fiscal year; (b) an evaluation of such activities in terms of the objectives set forth pursuant to Public Law 89-454; (c) such recommendations for legislation as the President may consider necessary or desirable for the attainment of the objectives of Public Law 89-454; and (d) an estimate of funding requirements of each agency and department of the Federal Government for marine science activities during the succeeding fiscal year.

This report on the Federal Ocean Program is submitted to the Congress in response to that requirement.

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Chapter I

THE FEDERAL OCEAN PROGRAM: A CONTRIBUTION TO NATIONAL SECURITY, THE QUALITY OF LIFE, AND THE GENERAL WELFARE

National security, the quality of life, and the general welfare are the chief concerns that underlie the Federal Ocean Program. Security implies economic as much as it does military strength. Economic strength is also essential to the enhancement of the quality of life, a concept difficult to define precisely but clearly dependent upon freedom of choice, both now and in the future. Decreasing conflict, strengthening the economy, and protecting the environment all act to improve the general welfare and to increase freedom of choice. These goals guide the determination of the priority components of the Federal Ocean Program, within the broader constraints imposed by limits on available resources.

Because the national goals upon which the Federal Ocean Program is based are long-term goals, the nature of the contributing elements of the program may not change significantly from year to year. Program emphasis, however, may shift somewhat from time to time, in response to changes in priorities.

This report features the contributions of the Federal Ocean Program to the fulfillment of two major national goals: the promotion of international cooperation and accord, and the development of new sources of energy to support our economy. These highlights are followed by reviews of major supporting elements that contribute broadly to the solution of continuing program needs or problems: description and prediction of the ocean environment in which the programs are to be carried out, and technological developments in support of the programs, with special emphasis on advances in data acquisition.

America is a seagoing nation with great dependence on the oceans that surround it. We can take pride in our past leadership and our accomplishments in marine science and engineering.

International Marine Affairs

The oceans, because of their inherently international character, their ready accessibility to many states, and their valuable resources, have long been major areas for conflict, both military and commercial. Advances in ocean science and technology have contributed to a growth of the potential for conflict, but these advances are also contributing opportunities for increased international cooperation, in such fields as research, environmental monitoring, reduction of pollution, development of energy and mineral resources, conservation and management of fisheries, and the promotion of safety and efficiency in maritime transportation.

The past year has been one of increasingly significant activity in international marine affairs, both within the United Nations and independently of it. The concerns of most widespread interest throughout the world are primarily the economic aspects of resource management and pollution abatement. Some encouraging steps have been taken to improve cooperation in solving questions of fisheries conservation and pollution control, although economic nationalism appears to be playing an increasing role in the politics of the oceans. The widespread conflicts generated over boundaries and regimes for control of fishing and mineral resources development impinge upon the interests of the developed maritime nations with respect to transport and trade, military security, and scientific research. Progress, under the auspices of the various international fisheries commissions, at the Stockholm Conference on the Human Environment and related meetings, and in bilateral cooperative research programs, is a feature of this year's report on the Federal Ocean Program. There still remain many important problems, however, in the UN Seabeds Committee and elsewhere. Preparations for the UN Conference on the Law of the Sea in 1973 and 1974 will continue to be a major activity in marine affairs.

Energy

A plentiful and assured supply of energy to support our economy is essential to the preservation of both national security and the quality of life. In the long term we anticipate increasing reliance upon nuclear energy, but short-and medium-term needs will require increasing use of fossil fuels, although our "onshore" petroleum production and reserves are declining rapidly relative to anticipated demand. Increasing use of coal is expected, but economy, convenience, and pollution control considerations dictate increasing dependence upon "offshore" sources of petroleum as well: the Eastern Hemisphere, Alaska, and the Outer Continental Shelf. In support of these urgent requirements, the Federal Ocean Program currently includes accelerated economic, engineering, and environmental studies of domestic deepwater ports and offshore terminals for supertankers. These will be required for the importation of large

quantities of oil from the Eastern Hemisphere at minimum cost both to the economy and to the environment. It is anticipated, however, that construction and operation of such terminals will be left to the private sector or to local public authorities. The requirement for importing oil from foreign sources can be reduced to some extent by increased production from Alaska and from the U.S. Outer Continental Shelf. Significantly enlarged studies of marine-related safety and pollution problems in production and transportation from these areas are components of the Federal program proposed for FY '74. Such studies will have an impact on accelerated leasing schedules on the OCS, as well as on the construction of deepwater ports.

Fisheries, Transportation, and Coastal Zone Management

Another important segment of the Federal program is support for the development of fisheries. Basic scientific studies and stock assessments and mapping have long been part of the program, not only as direct aids to the fishing industry, but also to provide the basis for more rational management and conservation. Closer attention is being paid to improving coordination and cooperation between the Federal Government and the States. As noted earlier, much effort has been devoted to improving international cooperation in the management of high-seas fisheries. As a result a large increase in the level of fishery treaty enforcement and surveillance activities is occurring in the current Federal program and will continue. The Secretary of Commerce's Marine Fisheries Advisory Committee, which is broadly representative of conservationists and commercial and sports fishermen, has urged high priority for this program as an effective means for protection of U.S. fisheries. An increase in the endangered species and marine mammals research programs is proposed, while support for the fish protein concentrate program has been discontinued.

Marine transportation continues as an important component of the Federal program. One major element is the provision and maintenance of harbors and navigable waters. Another consists of advanced ship engineering development and programs for improved economy, safety, and pollution control.

Programs directed toward improved management of the coastal zone, where industrial, residential, and recreational uses and conflicts continue to intensify, are aimed at wise and efficient long-term use of coastal resources. Coastal zone programs include pollution abatement and control, conservation and recreation activities, and comprehensive regional environmental systems research. The key to the solution of many coastal zone management problems is proper planning of land and water use. Recent legislation provides the impetus toward Federal technical and financial assistance to the States for this purpose. This serves as a critical first step along the way toward establishing more general land use policies.

Additional information on agency programs and budgets in the areas of international cooperation and collaboration, living resources, transportation, and coastal zone management will be found in the appendices.

Supporting Programs

We turn next in this report from programs directly associated with major national goals to some of those that provide essential support for the primary programs. One of these is common to virtually all marine activities, whether military or civilian, whether on the high seas or in the coastal zone, whether aimed at strengthening the economy or preserving the amenities: adequate description and prediction of the environment in which these activities take place. Observation and forecasting of the impact of the environment upon man's activities, as well as of man's activities upon the environment, are major elements of the Federal Ocean Program. Mapping, charting, and related data gathering activities in support of navigation, marine resource development, coastal zone management, naval operations, pollution studies, and the like continue to constitute a major portion of the overall program. These activities are also showing continuing needs for improved environmental forecasts, such as those provided by marine weather services. An increase in total funding and some shifts in relative priorities within the overall environmental description and prediction program is proposed for FY '74. An increase in nautical charting and coastal mapping budget proposals is accompanied by a decrease in geophysical mapping. Overall fiscal constraints require reduction or suspension of some of the lower priority programs.

Another major, multi-faceted supporting program is the development of the technology required to carry out primary programs. This includes, as part of the Federal Ocean Program, the development of satellite- or aircraft-borne remote sensing systems for gathering ocean-related data, as well as buoy-based data gathering systems. Technological developments are required for a wide variety of single- and multi-purpose applications. This report features developments in undersea technology for such applications as navigation, materials, construction, power sources, platforms, communications and control, salvage, and safety. An effort to provide improved manned and unmanned capabilities to perform research and other useful work at both diver depths and in the deep oceans is also being maintained. There have also been significant developments in other areas of marine technology, such as control of oily bilge-water discharge and other pollution from ships.

Increasing needs for atmospheric and oceanographic environmental information are stimulating development and use of remote sensing from satellites. The satellite systems development program, a major cooperative effort of the National Aeronautics and

Space Administration and the National Oceanic and Atmospheric Administration, already has shown significant accomplishments in environmental monitoring and prediction, with widespread applications to transportation, resource development, and pollution control. Current research and development programs show promise of further improvements. The remote sensing program is supplemented by an instrumented buoy development program needed to provide data on surface and subsurface environmental variables. Reliable operational prototypes for meteorological sensing are expected to be developed by late FY '74. Efforts to provide a capability to measure parameters indicative of the basic organic productivity of the oceans are also underway.

A program segment with major long-term implications for marine science affairs is the support of basic oceanographic research and education, together with the support of national centers and facilities. This program segment receives the largest funding of all the major categories of the Federal Ocean Program. While this funding decreased in FY '73, in part because of non-recurring expenditures for ships and other facilities in FY '72, the proposed budget for FY '74 resumes the historical increasing trend. The major funding agencies are the National Science Foundation, the Office of Naval Research, and the National Oceanic and Atmospheric Administration. Despite their wide diversity, covering all the major scientific disciplines, the broad outlines of these long-range oceanographic programs do not undergo major changes from year to year. They are not explicitly reviewed in this year's report.

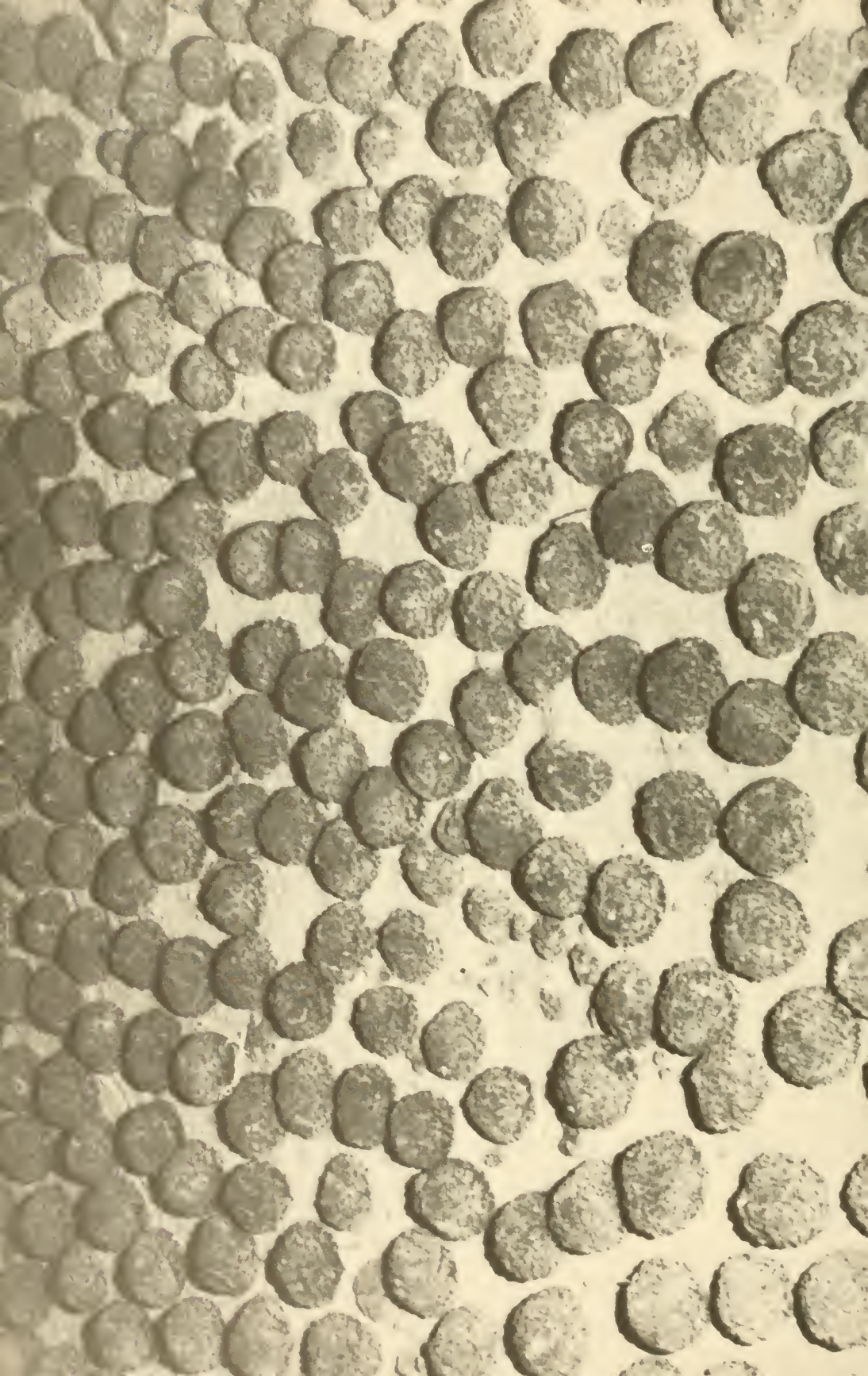
Recent Legislation

More than 20 laws directly affecting marine activities were enacted by the 92nd Congress. Their subject matter includes fisheries, marine mammals, water pollution, maritime safety, federal-state relationships and other institutional matters. The more important fisheries acts serve to implement a number of international agreements, promote conservation and development, and provide financial aid to commercial fishermen. P.L. 92-500, the Federal Water Pollution Control Act Amendments of 1972, has important long-range implications for estuarine and coastal waters, as well as inland waters. P.L. 92-532, The Marine Protection, Research, and Sanctuaries Act of 1972 (the "ocean dumping" bill), provides for regulation of the transportation of wastes to be dumped at sea, and for acceleration of research into dumping and ocean pollution effects. It is closely related to and to some extent anticipates implementation of the Ocean Dumping Convention that was opened for signature at the end of 1972. P.L. 92-340, The Ports and Waterways Safety Act of 1972, significantly increases the authority of the Coast Guard to control maritime traffic in the interests of safety and pollution control. P.L. 92-583, The Coastal

Zone Management Act of 1972, provides for the development of land and water use plans by state and local governments under Federal guidelines and support. As mentioned earlier, this planning is a major factor in establishing overall land use management. P.L. 92-522, The Marine Mammal Protection Act of 1972, prohibits the taking or importation of marine mammals, except under certain limited conditions. P. L. 92-125 authorized the National Advisory Committee on Oceans and Atmosphere, which submitted its first annual report to the President and the Congress in 1972. Summaries of these and the other ocean-related acts will be found in Appendix E.

Level of Effort

Actual and estimated funding levels for the Federal marine science program are tabulated in Appendix A. Overall funding in FY '73 is estimated to be about the same as in FY '72 in keeping with the President's program to curb inflation and avoid tax increases. For FY '74 an increase in funding to permit maintenance of an approximately equal level of effort is proposed. Appendix A-1 shows budget figures by agency, while A-2 summarizes the figures by major purpose. Appendix A-3 provides a more detailed breakdown by subpurpose and agency. Some of the changes, such as the current increase in treaty enforcement and the increase in research for FY '74, have already been noted. Others include increases within the national security program, in the leasing and management program for OCS non-living resources, and in environmental observation and prediction. There have also been of necessity some reductions. As noted at the end of the table, some of these, as in the coastal zone and national facilities programs, are the result of non-recurring capital expenditures by the Department of Transportation in FY '72 and in FY '73.



Chapter II

INTERNATIONAL ACTIVITIES

An essential element in the evolution of a strong federal ocean program during the 1960's was the strengthening of cooperation between nations engaged in maritime activities. However, international cooperation was insufficient to surmount the problems of the seventies arising from the accelerating competition for resources and increasingly serious ocean pollution. International recognition of these factors has stimulated a new emphasis toward the development of a more orderly regime for governing international ocean activities. The United States has been a leader in this effort and in the effort to improve international cooperation through existing organizations and by the negotiation of new bilateral and multilateral agreements. These efforts are the subjects of this chapter. Some of the scientific and technical aspects of international programs will be discussed elsewhere in the report.

Preparations for the Law of the Sea Conference

During the past year, the United States continued its involvement in the preparatory work for the forthcoming Law of the Sea Conference. In December 1972, the 27th United Nations General Assembly adopted a resolution calling for an opening organizational session of the Conference to be held at New York, N.Y., during a 2-week period in November and December 1973, to be followed by an 8-week substantive session at Santiago, Chile, beginning in April 1974. The 28th General Assembly, which convenes in the fall of 1973, will review the progress of the preparatory work for the Conference and, if necessary, adopt measures to facilitate the completion of the substantive work of the Conference.

Preparations for the Law of the Sea Conference are being undertaken by the 91 members of the U. N. Committee on the Peaceful Uses of the Seabed and Ocean Floor Beyond the Limits of National Jurisdiction (Seabed Committee). The activities of the Seabed

Manganese nodules, rich in copper, nickel, and cobalt, cover large areas of the ocean floor beyond national jurisdiction. Commercial development of these resources is linked to current international efforts to establish a legal regime for the seabed.

Committee are divided among its three subcommittees. Subcommittee I is concerned with the future regime for the seabed area beyond national jurisdiction and the powers and functions of international machinery to administer this area. Subcommittee II prepared a comprehensive list of issues for the Conference, including issues concerning the regimes of the high seas, the continental shelf, the territorial sea (including questions of its breadth), international straits, and fisheries. Subcommittee III is concerned with marine pollution and scientific research.

The Seabed Committee met in Geneva for 4 weeks in July and August 1972, in New York for 5 weeks in March and April 1973, and is scheduled to meet in Geneva for 8 weeks during July and August 1973.

At the July and August 1972 Seabed Committee meeting, Subcommittee I devoted four sessions to a debate on seabed machinery (i. e., the institutions and organization of the international seabed regime). Discussion centered on the scope, structure, and functions of the regime to be established. The United States continued to maintain that the international seabed authority should have only restricted licensing and management jurisdiction over seabed resources, and should not be permitted to explore and exploit seabed resources.

The U.S. Delegation indicated that the United States would be prepared to support the concept of broad coastal State jurisdiction over resources in adjacent waters and seabed areas beyond the territorial sea as part of an overall law-of-the-sea settlement if this coastal state resource management jurisdiction were subject to international standards. The standards would be designed to prevent unreasonable interference with other uses of the ocean, to protect against pollution, to protect the integrity of investment, to provide for arrangements for the sharing of revenues for international community purposes, and to require compulsory settlement of disputes.

A Working Group in Subcommittee I considered draft principles for a regime for the portion of the seabed beyond the limits of national jurisdiction, based in part on the Declaration of Principles adopted by the U. N. General Assembly in December 1970. The Working Group reviewed, during the July and August 1972 session, the draft proposals submitted to the Seabed Committee in an effort to identify areas of agreement and disagreement. It then produced a set of draft texts which reflected various points of view without resolving differences. Among the issues considered were the problem of definitions, the extent of the seabed area, questions of whether resources should be limited to mineral wealth or should include living resources as well, and whether resources are included in the concept of common heritage.

Within Subcommittee II, the United States continued to work vigorously towards an agreement which would set a maximum

width of the territorial sea at 12 miles, coupled with free transit through and over international straits. There appeared to be fairly general agreement on the 12-mile limit, but considerable differences remained on the question of free transit through international straits. On July 28, 1972, the United States made several proposals designed to meet straits states' concerns regarding navigational safety of ships and aircraft when exercising the right of free transit. It was emphasized that the right of free transit is limited to transit only and that the United States was willing to observe reasonable traffic safety regulations consistent with the basic free transit right. These regulations must be internationally agreed upon, not imposed unilaterally by coastal states. The United States suggested that the Intergovernmental Maritime Consultative Organization (IMCO) and the International Civil Aviation Organization (ICAO) were the best international organizations to establish such regulations. It was proposed that the convention provide: (1) for mandatory IMCO traffic separation schemes for vessels; (2) that states exercising free transit rights over straits normally respect ICAO civil aircraft standards and at all times operate with due respect for navigation of civil aircraft; and (3) for strict liability when accidents are caused by deviations from IMCO and ICAO rules.

The United States submitted a revised fisheries draft article at the Summer 1972 session of the U.N. Seabed Committee. The draft advocates the species approach as the best method of assuring rational use and conservation of all fish stocks. It provides that coastal states be granted effective control over conservation and exploitation of adjacent coastal species, including inspection and arrest authority. This control would extend as far offshore as the range of each fish stock. The coastal state could reserve for itself as much of the allowable catch as it could utilize. The remainder would be made available for catching by fishermen of other nations, subject to conservation measures and reasonable management fees of the coastal state. The extent to which coastal state fishing preference would diminish traditional distant-water fishing would be determined through negotiation between the coastal and distant-water fishing states on the basis of criteria to be agreed upon at the Conference. Anadromous species, such as salmon, would be handled in the same manner as coastal species, with the state of origin exercising control throughout their migratory range. Highly migratory ocean stocks, such as tuna, would be managed by international organizations in which all fishing states and interested coastal states could participate. A compulsory dispute settlement procedure within a special commission would be provided.

The United States believes that the species approach accommodates the interests of both coastal and distant-water fishing states and takes into account the biological characteristics of the fish. Thus, the United States supports broad coastal state jurisdiction over coastal and anadromous fisheries beyond the

territorial sea subject to international standards designed to ensure conservation, maximum utilization, and equitable allocation.

With regard to marine pollution, the United States proposed, at the July and August 1972 session, that Subcommittee III focus attention on basic legal principles which could be drawn from the conclusions of the United Nations Conference on the Human Environment, held in Stockholm, June 5-16, 1972. Such principles could form the basis for general treaty articles. The United States urged the Subcommittee to concentrate on controlling pollution from vessels and identified several important steps to be taken in this regard to support IMCO's activities. The United States also suggested that the Subcommittee urge IMCO to give greater consideration to coastal states' concerns and proposed that IMCO should require all new commercial tankers to carry an international construction certificate with port-state verification of possession. The U. S. Delegation further proposed that international traffic separation schemes, which are now voluntary, should be mandatory for all ships, with strict liability for accidents caused by deviations from IMCO regulations. The United States also suggested that the 1969 Intervention Convention, which gives coastal states certain limited rights to take actions on the high seas to prevent oil pollution of their coastlines following maritime accidents, should be expanded by IMCO to apply to other noxious substances.

Subcommittee III established a Working Group on marine pollution. The Group has a mandate to examine the Stockholm Declaration on the Human Environment and the Stockholm principles on marine pollution with a view towards drafting articles on marine pollution for a law of the sea treaty.

The issue of scientific research was addressed by the delegations of 18 nations during the July-August 1972 meeting of Subcommittee III. The African, Asian, and Latin-American nations in general took a position which did not recognize the freedom of scientific research. They felt, instead, that all research should be regulated by the coastal state or an international regime to be established. This stance against the freedom of scientific research by African, Asian, and Latin-American nations stems from their belief that the developing nations derive no economic benefits from the research conducted off their coasts by the developed countries.

In contrast to the views of African, Asian, and Latin-American nations were the positions of the developed nations, such as the United States, Japan, and generally speaking, the nations of both Western and Eastern Europe. These nations wanted no additional restrictions on the freedom to conduct scientific research, or they wanted such restrictions to be kept to a minimum. They also generally desired to adopt principles or guidelines which would facilitate research within waters under the control of the coastal state. They generally recognized the importance of transferring marine scientific knowledge and technology to the developing

countries so that the latter may benefit from advances in the marine sciences.

The United States is prepared to explore practical means whereby technical assistance can be improved in the field of marine science education and technology transfer. We have indicated our willingness, in principle, to commit funds to support multilateral efforts in all appropriate international agencies with a view towards creating and enlarging the ability of developing states to interpret and use scientific data for their economic benefit and other purposes.

Marine Pollution

International recognition of increasingly serious ocean pollution has stimulated the development of treaties and regulations to control dumping at sea and to prevent ship collisions and ensuing cargo and fuel release. By participating in the development of these regulations the United States and other nations hope to improve protection of the marine environment.

One of the recommendations of the Stockholm Conference was to convene a conference on ocean dumping with a view toward drawing up a treaty. Such an intergovernmental conference was held in London, October 30-November 13, 1972, and succeeded in completing an Ocean Dumping Convention. Extensive preparatory work for the Conference was accomplished by an Intergovernmental Working Group on Marine Pollution at meetings held in Reykjavik in April 1972 and London in May 1972.

The Ocean Dumping Convention regulates the dumping of wastes at sea from vessels, aircraft, platforms, and other man-made structures when the wastes are not derived from the normal operations of such craft. The dumping of certain hazardous materials, high-level radioactive wastes, persistent synthetics, chemical and biological warfare agents, and oil taken aboard vessels for the purpose of dumping is prohibited. An exception to this prohibition is allowed only in emergencies posing unacceptable risks to human health and admitting no other feasible solution. The dumping of other wastes is to be regulated by means of national permit systems created under domestic legislation by each of the Contracting Parties to the Convention.

The Convention was opened for signature on December 29, 1972 at Washington, Mexico City, London, and Moscow. After fifteen nations have ratified the convention, a meeting of the Parties will be held to establish organizational procedures and to select an existing international organization to carry out secretariat duties. President Nixon in his Environmental Message to Congress in February 1973 requested the Senate to advise and consent to the Convention.

During 1972, the United States played a leading role within the Intergovernmental Maritime Consultative Organization (IMCO). The organization is attempting to deal in a comprehensive way with

the various aspects of the problem of pollution from ships. In October an IMCO-sponsored conference completed work on the 1972 Convention on the International Regulations for Preventing Collisions at Sea, which revised, expanded, and made binding on all parties the international regulations governing safe navigation precedures and shipping traffic lanes. It is expected that this Convention and the further development of IMCO traffic separation schemes will reduce the likelihood of maritime accidents and thus the potential for pollution damage to coastal areas.

Preparations are also continuing in the IMCO Legal Committee for the completion in 1973 of a protocol expanding the 1969 Intervention Convention, which presently deals only with oil, to other harmful substances. The Convention now gives coastal states the right to take action on the high seas as may be necessary to prevent, mitigate, or eliminate grave and imminent danger to their coastlines or related interests from pollution of the sea by oil, following maritime casualties which may reasonably be expected to result in major harmful consequences. The United States suggested expansion of the Convention at the summer 1972 Seabed Committee meeting.

Intensive preparations were also made during 1972 by the IMCO Subcommittees on Marine Pollution and Ship Design and Equipment for the completion in 1973 of the proposed Convention for the Prevention of Pollution from Ships. In its present draft form, this Convention would replace the existing 1954 Oil Pollution Convention with stricter regulation of oil discharges. It would also regulate those aspects of ship construction and operating procedures which contribute to the deliberate or accidental release of oil. Furthermore, the Convention would regulate the carriage and discharge of other harmful substances, and in some cases the construction and operation of ships carrying such substances, as well as place controls on the discharge of sewage and garbage from vessels.

Within IMCO preparations have begun to put together the machinery necessary to efficiently administer the Fund created by the 1971 Compensation Fund Convention to compensate victims of oil pollution damage from ship discharges.

International Marine Science Organizations and Bilateral Agreements

Although UNESCO's Intergovernmental Oceanographic Commission has been operating for over a year under new statutes which broadened its responsibilities, the Commission's work has been productive only in a few areas, such as the Cooperative Investigations of the Caribbean and Adjacent Regions (CICAR), the development of the Integrated Global Ocean Station System (IGOSS), and the international exchange of oceanographic data. The Commission's lack of activity in other areas can be attributed to a

number of factors, including the vacancy in the post of IOC Secretary from November 1971 until October 1972 and a wait-and-see attitude on many ocean science programs by some nations until issues can be settled by the U.N. Law of the Sea Conference.

During 1972, the United States unsuccessfully urged the Commission—and UNESCO as the Commission's basic sponsor—to provide strong support for both the International Decade of Ocean Exploration (IDOE), particularly the Global Investigations of Pollution in the Marine Environment (GIPME), and the IOC program in mutual assistance, training, and education. At the 17th General Conference of UNESCO, which approved the IOC work program and budget for the next two years, many countries strongly supported U.S. efforts to emphasize the IOC program in mutual assistance, training, and education, but our efforts to emphasize GIPME gained less support.

The first meeting of the reconstituted IOC Executive Council in July 1972 made disappointing progress on most issues before it. An International Coordination Group for GIPME was established by the Council, but, in spite of the urgency attached to this program by many members, it was not possible to organize the Group or to schedule its first session until April 1973.

Particularly disappointing was the failure to streamline the Commission's internal structure to increase its efficiency. A hopeful note was found in the Council's decision to establish an Ad Hoc Study Group to take an intensive look at improving the effectiveness of the Commission across the Board. The Group's meeting in January 1973 produced several important recommendations, which, if implemented, should significantly improve the efficiency of the Commission and enable it to function better as the focal point for international marine science activities. Among these were development of a work program and financial requirements, which will establish priorities and lay the base for obtaining resources needed for the IOC's work; a restructuring of the Commission's subsidiary bodies to enhance their work; and the establishment of formal working relationships with other international organizations, such as the Food and Agriculture Organization, the Intergovernmental Maritime Consultative Organization, and the World Meteorological Organization.

The United States also continued its efforts through other mechanisms to achieve the coordination needed between our oceanographic program and those of other nations. One such mechanism is the U.S.-French bilateral program, under which U.S. and French oceanographers are planning to cooperate in a series of projects over the next few years, including studies of the Mid-Atlantic Ridge, aquaculture, buoy technology, and abatement and control of marine pollution.

During 1972 a number of countries initiated cooperative efforts with the United States under the IDOE program, but outside the IOC.

These efforts include projects in the areas of environmental quality, environmental forecasting, and seabed assessment. Other countries participating in these projects thus far include Canada, France, Germany, India, Italy, Japan, and the United Kingdom. Additional studies in the area of living resources will soon be underway. It is expected that many other nations, especially those African and South American nations bordering the South Atlantic, will participate in various IDOE programs over the next few years.

The United States continued its active participation in the marine science programs of the International Hydrographic Organization and the various international fisheries commissions. During 1972 NATO undertook a comprehensive review of its oceanographic research program for the purpose of revising it extensively over the next year.

In April 1973 the United States became a member of the International Council for the Exploration of the Sea (ICES), the oldest international organization dealing with fisheries and marine sciences, dating from 1901. The U.S. became a member in 1912, but terminated its membership during World War I. In recent years we have participated in ICES meetings and scientific projects in an observer status, but our participation was handicapped by lack of full membership. The United States is the last major oceanic nation in the North Atlantic region, the center of ICES activities, to become a full member. This action should significantly enhance the effectiveness of our planning and execution of scientific work in the North Atlantic.

Foreign Relations Aspects of United States Fisheries

Jurisdictional disputes between U.S. fishermen and foreign governments continued to be a major issue. U.S. tropical tuna fishermen operating in certain foreign-claimed waters have been subjected to seizures and fines. The U.S. fishermen are viewed by developing foreign nations as representatives of a developed country exploiting resources off their shores. Consequently extensions of jurisdiction and other coastal state measures have been implemented to foster development of their own fishing industries by restricting the activities of distant-water fishermen. Continuing diplomatic efforts to resolve the jurisdictional dispute of 20-years' standing with Ecuador and Peru in the eastern Pacific tuna fishery failed to achieve a settlement. Seizures continued at a high level in 1972, with Ecuador seizing 25 U.S. seiners and assessing a total of \$1.7 million in fees.

Congress and Government agencies took action to aid U.S. fishermen whose vessels and gear were seized or damaged by foreigners. The tuna industry was helped by Congressional action in late 1972, when the Fishermen's Protective Act was amended. This change expedited compensation for losses caused by illegal seizures and

tightened up the requirement for offsetting reductions from aid funds programmed for the seizing governments. Congress also authorized appropriation of funds to support tuna fishery development activities in Micronesia.

The United States distant-water fishermen who operate off north-eastern South America were assured of continued access to their accustomed fishing grounds within the 200-mile territorial sea claimed by Brazil by the signing of a shrimp conservation agreement between the United States and Brazil on May 9, 1972. The United States agreed to limit the number of its flag vessels in the fishery for conservation purposes. The agreement requires only voluntary compliance until passage of implementing legislation in the United States. The agreement was a successful compromise between countries having widely disparate positions on fishery jurisdiction, and should make it possible to avoid another dispute like that which has troubled the tuna fishery on the west coast of South America. It is also noteworthy that both the United States and Brazil could reach agreement while preserving their judicial and law of the sea positions pending an international solution at the Law of the Sea Conference.

Foreign fishing vessel interference with deepwater lobster pots off the Atlantic coast continued to be a problem. Vigorous action by the U.S. Coast Guard and National Marine Fisheries Service in cooperation with the Department of State helped alleviate conflicts with foreign fishermen. In an effort to minimize gear conflicts, daily messages were sent to foreign fleet commanders identifying areas where U.S. lobster pots were located. These actions tended to diminish the problem somewhat. Assistance was rendered to American Fishermen in preparing and presenting damage claims



U.S. Government officials and lobster fisherman discuss lobster pot interference with USSR fishing fleet commander and staff.

against foreign fishing vessels, and some have been settled successfully.

International regulation continues to be part of the fisherman's life. Strong competition for dwindling stocks in established fishing areas prompted the United States and other nations to seek more equitable arrangements through international fishery commissions. The response has been the establishment of new or reduced quotas, size limits, and inspection schemes, as well as a new technique for allocating quotas.

The International Commission for the Northwest Atlantic Fisheries (ICNAF), under the authority of the December 1971 amendment to the ICNAF Convention, adopted at a February 1972 Special Meeting national quota regulations for the depleted herring stocks off the United States and Canada. These regulations, which became effective in September 1972, represent the first national catch quota scheme applied in a major, multinational fishery. For the first time the regulations were formulated using economic and technical considerations as well as the basic scientific criteria historically used in fisheries management. One basis for allocation was preference for coastal fisheries, thus helping to redress the competitive disadvantage of the U.S. coastal fishing vessels against foreign ocean-going fishing vessels. This step may be the most significant move since the inception of international fisheries management many years ago. A second Special ICNAF Meeting in January 1973 modified and extended the herring quota scheme through 1973.

At its regular annual meeting in June 1972, ICNAF took steps to extend this method for formulating fisheries allocations to other species and fishing areas where some depletion or a potential for depletion exists. This action was an attempt to head off problems before they materialized. Of the 23 regulatory proposals adopted at the Annual Meeting, 18 dealt with quotas for the 1973 season, and 15 of those allocated quotas among member nations. Allocations were made for three of the stocks among all (then) 15 members of the Commission. The quotas became effective on January 1, 1973, for the 1973 season.

Monitoring of foreign fishing operations off our coast showed that the fishing effort was significantly increased in 1972. This expanded activity threatened to undermine progress on national quota allocations and posed a serious danger that small stocks available to U. S. coastal fisheries might be decimated by incidental catches. The size of the effort might also disperse stocks, thus making it difficult or impossible for the small American fishing vessels to operate economically. Accordingly, the United States issued an urgent call in October 1972 for a special ICNAF Meeting in January 1973 to consider limitation of fishing effort. That meeting failed to reach agreement on the U.S. proposal to reduce and control fishing effort, but did not reject it. A special expert group was established by ICNAF to study the many difficult and complex questions posed by the U. S. proposal so that the Commission may consider it further.

The experts met in Woods Hole, Massachusetts, March 26-30, 1973. As an interim control measure, ICNAF adopted national quota regulations on four more previously unregulated species to help cut back on the build-up of effort. Thus, virtually all species in the ICNAF area will be under quota regulation.

The first full year of operation of the ICNAF International Inspection Scheme was 1972. Under the scheme enforcement officers of one nation are allowed to board other ICNAF members' fishing vessels on the high seas to check for compliance with ICNAF regulations. Under maritime practice, enforcement against vessels at sea is a prerogative usually reserved to the flag nation. The ICNAF scheme, together with a similar one under the sister Northeast Atlantic Fisheries Commission, both involving 20 nations as diverse as Japan and Iceland, the Soviet Union and Portugal, and Canada and Romania, demonstrate that it is possible for nations to cooperate in mutual policing of activities of common concern. Numerous inspections carried out during the year were without incident, and no major infractions of the ICNAF regulations were reported.

The controversial debate on curbing the high seas Atlantic salmon fishery was resolved in 1972 when ICNAF adopted a regulation which will phase out the fishery by January 1, 1976. The regulation became effective on December 23, 1972. As a result, the resource will no longer be threatened by direct high seas fisheries which could destroy the stock and which had severely depleted some salmon spawning rivers.

The International Commission for the Conservation of Atlantic Tunas adopted its first conservation recommendation, a size limit for yellowfin tuna, at its fourth regular meeting in December 1972. The United States and 11 other countries are members of the Commission. In addition, present and anticipated conservation restrictions and sharpening competition in established fishing areas, coupled with the problems posed by extensions of Atlantic coastal state jurisdictional claims, caused the tuna fishermen to show an increasing interest in developing new fishing grounds in the central and western Pacific Ocean and the Indian Ocean.

The waters off our Pacific coast continued to be major fishing grounds for foreign vessels, particularly those of Japan and the Soviet Union. In areas off Alaska, vessels of those two major fishing nations number in the hundreds during certain seasons of the year. In addition, vessels of the Republic of Korea trawl-fished the eastern Bering Sea, though to a much lesser degree than those of Japan and the Soviet Union. Most foreign fishing effort has been devoted to a number of fish species which are not now greatly sought by U.S. fishermen. However, the United States is very concerned about conserving these fish stocks as resources for the future. Consequently, the United States means to assure their conservation.

For example, the United States sought to broaden research efforts and data exchanges through the International North Pacific Fisheries Commission (made up of the United States, Canada, and Japan) to apply to stocks of fish to which the Commission has

heretofore given little attention. This effort has faced difficulty, however, because the treaty under which the Commission operates limits the study of stocks to those which are under substantial exploitation by two or more contracting parties. The treaty was negotiated primarily to protect salmon and halibut at a time when the enormous new fisheries for other species were not foreseen. Despite its deficiencies, however, this treaty, together with additional agreements between the United States and other countries fishing the North Pacific, has generally served to provide significant protection for U.S. salmon interests, to reduce conflicts among fishermen, and to increase the flow of biological and fisheries data. However, certain groundfish resources, especially halibut and Pacific Ocean perch, remain in jeopardy.

Fishermen of the Republic of Korea entered into the northeastern Pacific salmon fisheries in 1969 and 1970, creating considerable apprehension in the U.S. fishing industry. The United States reviewed this problem with Korea, and the two Governments signed a 5-year agreement in December 1972, which prohibits South Korean fishermen from fishing for salmon or halibut in the northeastern Pacific Ocean and eastern Bering Sea.

In December 1972, the United States reviewed two bilateral agreements with Japan and signed new versions which provide additional protection for U.S. coastal fishermen and improved conservation measures. In one agreement, particular progress was made in improving the opportunities for U.S. fishermen to have unimpeded access to, and to play the major role in, the fisheries for king and tanner crab in the eastern Bering Sea. The other agreement, which was initiated in 1967 following the establishment by the



Purse seining, surrounding a school of fish with a large net and drawing it together, has become the primary commercial method of catching salmon in the Alaskan region.

United States of a contiguous fisheries jurisdiction zone extending 9 miles beyond the 3-mile territorial sea, provides certain limited privileges within this zone for fishing and cargo-transfer operations by Japanese vessels, in return for which Japan agrees to certain limitations on its fishing activities on the high seas outside the zone. In an understanding related to the review of this latter agreement, Japan also agreed not to undertake specific fisheries for lobster off our Atlantic coast and agreed to attempt to minimize the incidental catch of lobster.

Similar bilateral agreements with the Soviet Union were reviewed in February 1973. The new versions of the US-USSR North Pacific agreements include substantial conservation improvements from the U.S. point of view, especially limits to the Soviet catch of certain species. The two countries also negotiated and signed a new agreement initially applicable to the northeastern Pacific Ocean. It provides for consideration of claims resulting from damage to fishing vessels or gear during fishing operations of the two countries by claims boards with joint membership. The boards will consider claims voluntarily submitted by either side and will seek conciliation through fact finding. Judicial rights of U.S. and Soviet nationals remain unaffected. The countries adopted a set of interim rules to govern the conduct of fishing and prevent conflicts until further negotiations.

Renegotiation of the Mid-Atlantic bilateral fisheries agreement with the USSR was initiated at a meeting in Moscow in February 1973. Most matters were resolved successfully. However, because it was not possible to reach agreement on two points, it was decided to extend the existing agreement through June 30, 1973, and to meet then to conclude the renegotiation.

The Soviets made it clear that they had no plans to initiate a lobster fishery and would take measures to reduce incidental catches of lobster and to return to the sea in a viable condition all lobster taken incidentally, insofar as possible. This commitment, among others from the USSR, is contingent upon resolution of the remaining Mid-Atlantic fishery issues at the meeting in June 1973.

A similar Mid-Atlantic bilateral fisheries agreement with Poland was extended on October 1, 1972, through June 30, 1973. It provides protection for species of interest to U.S. fishermen.

The five-year agreement with Mexico on reciprocal traditional fishing privileges within the 9- to 12-mile zone off both countries terminated at the end of 1972 without immediate prospect of renewal. The U.S. shrimp catch in this area, however, had accounted for only a minor portion of the total U.S. shrimp catch.

Although the United States was unable to bring about a moratorium on whaling, it did effect changes in the International Whaling Commission's conservation program. At the 1972 meeting of the International Whaling Commission, the United States delegation made strenuous efforts to obtain agreement on a blanket moratorium on commercial whaling. These efforts were consistent with domestic actions to prohibit commercial whaling by U.S.

citizens and importation of whale products, as well as with U.S. efforts at the U.N. Conference on the Human Environment that resulted in a vote favoring a whaling moratorium. The U.S. delegation, however, was unsuccessful in obtaining the necessary three-fourths majority for approval within the Whaling Commission. Nevertheless, the strength of the support for the U.S. proposal created an atmosphere which made it possible to achieve further improvements in the Commission's conservation program.

Significant reductions were made in the catch quotas for fin whales in the North Pacific and Antarctic, which should enable the depleted stocks of this species to recover to some degree. Quotas were also reduced for sei whales in the Antarctic and North Pacific and for sperm whales in the North Pacific. For the first time, quotas were imposed on the capture of sperm whales in the Southern Hemisphere and minke whales in the Antarctic. It is significant that a precautionary quota was imposed for the minke whales since they have been exploited to only a slight degree.

The Commission, in accordance with previous commitments, eliminated the combined quota for Antarctic baleen whales. Separate quotas for fin and sei whales were established to enable more precise management. As previously recommended by the Commission, a system of international observation for regulation enforcement went into effect in 1972. In other actions, a number of proposals made by the U.S. delegation were adopted to increase the effectiveness of the Commission's conservation program.



Precautionary quotas established by the International Whaling Commission on minke whales assure the survival of this species.

Assistance to Developing Countries in Marine Science and Technology

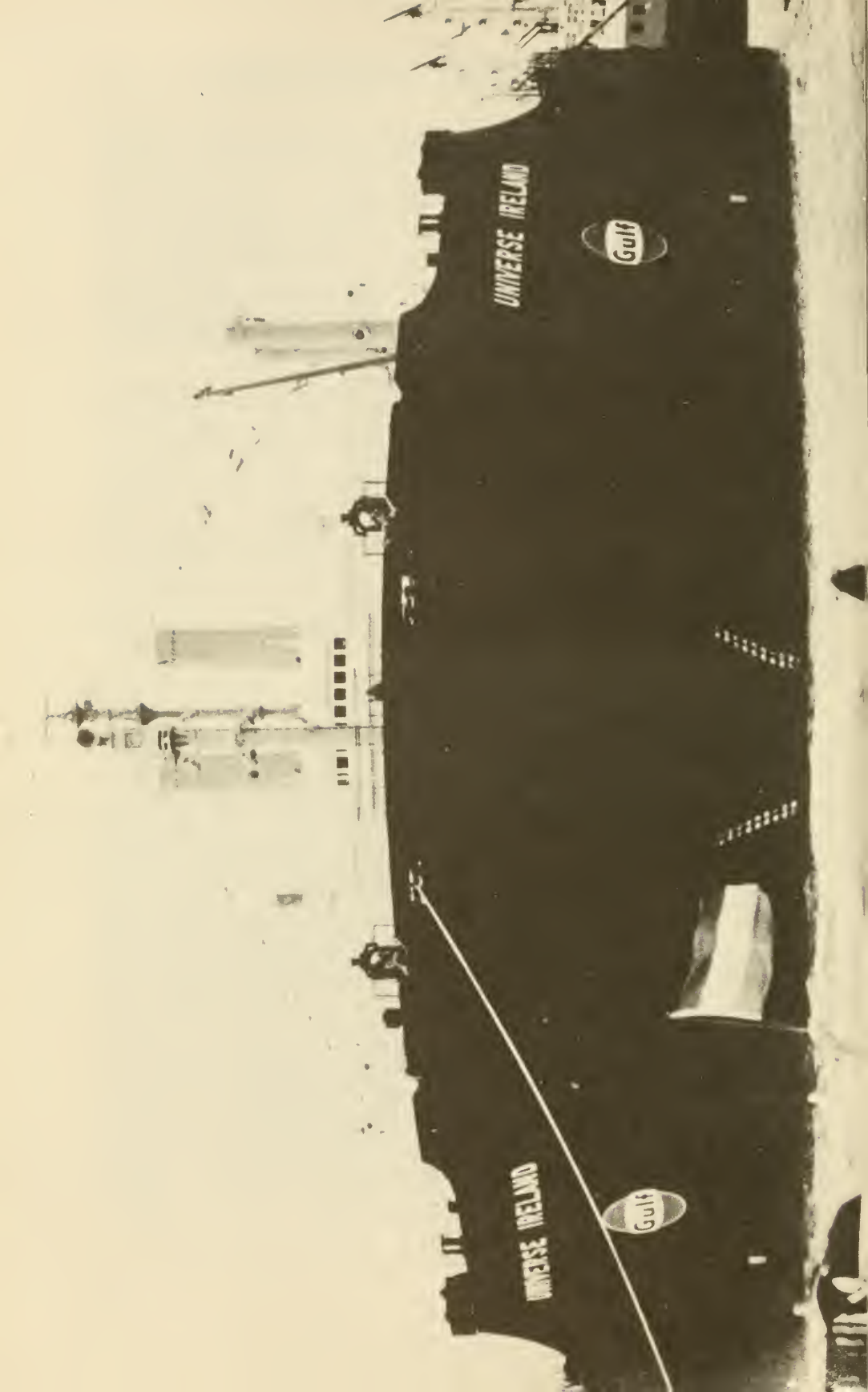
The Agency for International Development (AID) did not initiate any new marine programs of significance during the past year. Modest supplementary funds were provided to NOAA's National Oceanographic Data Center to conclude the AID-funded collaborative program with UNESCO to train developing country marine scientists in ocean data acquisition, processing, and utilization. Twenty-three trainees from sixteen developing countries completed the course. As the demand remains high for this mutually beneficial program, it will be reestablished for at least one year more under funding from the Office for the International Decade of Ocean Exploration within the National Science Foundation.

A policy determination was recently made that the National Oceanographic Instrumentation Center of NOAA would provide advisory services to both developing and developed countries in matters relating to instrument calibration, testing, and testing facilities, and, on a cost-reimbursable basis, provide as feasible actual calibration and testing services, including training. The United States recently made available to the Intergovernmental Oceanographic Commission 100 mechanical bathythermographs for distribution to developing countries. An IOC working group has recommended that other nations follow suit.

In response to repeated requests by the CICAR countries for opportunities for their marine scientists and students to obtain at-sea training, NOAA planned and carried out NOAA-Carib. The cruise extended from October 9 to December 15, 1972, and included cooperative work with scientists and students from Mexico, Jamaica, Puerto Rico, Trinidad and Tobago, Venezuela, and Colombia, plus one man each from the Netherlands Antilles and France. NOAA-Carib was set up to accomplish research work planned completely by the participating nations. Participating scientists from each country decided what research work would be done, where it would be accomplished, and which of their own people would take part.

In addition to the actual research work at sea, the major port stop in each country included a one-day education and training cruise for 50 to 60 students. A total of 401 Latin-American scientists and students received at-sea training aboard the *Discoverer* during NOAA-Carib for periods ranging from one day to two weeks.

Through arrangements made with the U.S. Navy, 23 reconditioned and calibrated mechanical bathythermographs were provided to the NOAA ship *Discoverer* for distribution to the participating Latin-American countries. These were presented to Mexico, Jamaica, Trinidad and Tobago, Venezuela, and Colombia in ceremonies at the end of each one-day cruise. In addition, NOAA's National Marine Fisheries Service provided sets of bongo nets and neuston nets to Colombia and Venezuela so that the results of their plankton sampling will be compatible with those of other CICAR nations by utilizing these standard CICAR nets.



Chapter III

ENERGY

The United States will of necessity continue to rely heavily upon petroleum and natural gas to meet rising energy demands for some years to come. Oil and gas supplies must be augmented rapidly, in a manner consistent with our economic, environmental, and security interests, despite recent declining trends in domestic production.

The available sources for increasing supplies are primarily imports from foreign areas having excess production capacity, Northern Alaska reserves, and the large untapped potential reserves of the nation's continental shelves and adjacent slopes. Imports and offshore oil production necessarily involve marine operations, as will also tapping Alaskan reserves if we are to minimize further increasingly serious delays in bringing Alaskan crude to our refineries. The Federal Government and industry share an interest in these sources and are strengthening their associations in an effort to expedite delivery of supplies from all three. No one of them is adequate to meet projected demands for hydrocarbons, even if supplemented by "synthetic" crude and natural gas from oil shale, coal, or other sources.

Of these three sources, increasing imports is the one most readily available to meet current and near-term shortages. Three to five years will be required to complete construction and begin delivery of oil through the Trans-Alaska Pipeline System (TAPS) and to find, explore, develop, and produce new oil fields on the continental shelves. Supertankers or "VLCC's" (very large crude carriers) and LNG (liquefied natural gas) carriers can provide the most economical and environmentally desirable means of delivering imports from distant areas, such as the Middle and Near East, which are currently the only regions with sufficient producing capacity to fulfill our Nation's demands. The VLCC's require deepwater ports. Planning for these ports and for supporting facilities to handle and process their cargo requires consideration of many factors to assure efficient operations and to minimize risks to the environment.

Economic impacts and environmental concerns, as well as security considerations associated with the import of oil and gas from foreign areas, provide strong incentives for accelerated development of

Shown bow on, this supertanker, 326,000 tons, has a length of 1,135 feet and a loaded draft of 80 feet. (Gulf Oil Corp. Photo—Courtesy of American Petroleum Institute)

domestic resources. Construction and full-scale operation of the Trans-Alaska Pipeline System, which includes marine transportation from Port Valdez, Alaska, to various west coast ports, will provide two million barrels of oil daily, a rate equal to one-third of present import levels. Our interest in rapidly increasing our supply of domestic oil and in reducing the balance of payments problem associated with imports will be best served by the Alaskan pipeline. As part of the overall transportation problem, the Federal Government is planning programs to detect and control oil spillage or other pollution and to augment forecasts of marine weather and operating conditions along the tanker routes.

For a number of years, increasing domestic offshore oil and gas production has slightly more than offset an accelerating decline in onshore production. In 1972, however, total domestic petroleum production began declining, while the demand for oil products continued to increase. The growth in demand necessitated lifting import quotas to avoid possible shortages. Future oil imports will be subject to license fee rather than quota. The untapped petroleum potentials of the continental shelves appear large, and if developed more rapidly, would significantly improve levels of total domestic production. Within a given region, development of reserves to meet national needs must be balanced against a number of economic, social, and environmental factors, such as other uses of promising areas (including uses related to recreation, esthetics, and national security), and natural conditions and hazards that may affect safety of the operations. With industry cooperation, the Federal Government is intensifying efforts to identify and lease the most promising regions, and to collect and evaluate data that will enable sound resource management decisions.

In the following sections, marine technological aspects of the petroleum supply problem are discussed in more detail.

Deepwater Ports

The expanding fleet of supertankers that now serves Europe, Japan, and other foreign areas having deepwater ports has demonstrated the economy and other benefits of transporting oil by this means. Using supertankers rather than smaller vessels to deliver oil from the Middle East to the Atlantic and Gulf coasts of the United States would allow major savings in transportation costs.

Although cost savings and other economic benefits will be significant, a major advantage of the use of supertankers is the smaller number of ships and operations required, thereby lessening the chances of oil spillage through collisions or cargo handling. Offshore placement of the superports would offer the added advantages of reducing risk of groundings, traffic density, and potential damage to beaches and the nearshore. Yet another environmental advantage of offshore superports is that they will permit the use of new VLCC's with double bottoms and segregated ballast tanks.



No existing U.S. Port can handle supertankers like this one, shown at launching.

(Exxon Corp. Photo—Courtesy of API)

Establishing the feasibility of deepwater port systems involves not only economic, engineering, environmental, and operational factors for the offshore terminal itself, but also such other considerations as distances to markets, availability of sites for storage or refining facilities, and routes for interconnecting pipelines. Past and continuing activities within the federal marine science and engineering program have provided much essential basic data for relevant studies.

The Corps of Engineers was authorized by Congress to conduct regional deepwater port studies on the North Atlantic, Gulf, and Pacific coasts to determine efficient, economic, and logical means of developing facilities to accommodate very large bulk cargo carriers. This authorization resulted from the growing concern over the adequacy of present U.S. harbor and channel facilities to accommodate the future needs of our waterborne commerce, much of which will be moving in these supersize ships.

Prior to the initiation in FY '72 of the regional deepwater port studies, the Corps of Engineers undertook two major research efforts to provide an overall appraisal of U.S. deepwater port needs. The first research, completed in December 1971, provided an assessment of foreign experience with deepwater port development. The second major research, completed in August 1972, examined the overall need for deepwater ports. It concentrated on identification of the factors critical to U.S. deepwater port decisions, on development of the engineering, economic, and environmental criteria appropriate to the evaluation of deepwater port policies, on analyses of the development options available at this time and the critical issues surrounding each, and on identification of the critical issues which need further analysis.

Interim reports for the regional deepwater port studies are nearing

completion and will be concerned with unique conditions in the respective regions under study. Each report will strive to achieve two common objectives:

(1) Demonstrate the net advantage or disadvantage to the employment of supership technology, and,

(2) In the event of adequate net advantage, identify the most likely or most feasible sites or locations for the employment of supership technology within the respective regions under study; or conversely, identify the most likely transportation system alternatives and associated problems in the absence of deepwater port facilities.

The studies will evaluate the feasibility of possible sites along the Atlantic, Gulf, and Pacific coasts for three types of deepwater port facilities. Monobuoys, the least expensive type, provide single-point moorings and connections by hoses to submarine pipelines that lead to shore-based storage tanks. Ship handling problems are relatively simple. Far offshore, clusters or arrays of monobuoys may be located around a booster pumping station on a small platform. Mooring platforms are larger structures that keep ships in fixed positions during unloading, and from which oil is pumped to shore through submarine pipelines. They permit rapid and controlled transfer operations but require tugs to assist tanker berthing and possible curtailment of activities during rough seas. Artificial islands constitute the most elaborate and expensive offshore facilities but could serve a greater number of purposes, including space for storage tanks, employee housing, and possible recreation sites. The studies have also evaluated the alternative of dredging deeper channels in some of the regions.

Other Federal and state agencies, and industry, have contributed to coordinated studies with the Corps to establish the most feasible solutions to the need for deepwater ports. The Maritime Administration has supported a study of concepts and potential sites for artificial islands along the Atlantic and Gulf coasts. The Coast Guard has undertaken analyses of the anticipated effects of deepwater ports and use of supertankers on management of vessel traffic, incidence of accidents, and control of potential oil spillage. The Department of the Interior assembled pertinent environmental, engineering, and operational data for offshore oil platforms and pipelines as a guide to the analysis of deepwater port impacts.

Results of studies undertaken for other purposes also proved to be useful. Studies of offshore airports, powerplants, and waste disposal, or of wave effects on offshore structures, have obvious relevance. Others, such as offshore cities, aquaculture, and seafloor habitation, may seem less pertinent but have led to results and interpretations that also apply to deepwater port considerations.

Academic institutions, industry, and the public have also contributed to agency and interagency studies of deepwater port concepts. The Sea Grant Program of NOAA, under the guidance of the Council on Environmental Quality, supported investigations of potential environmental impacts of offshore terminals. With direct interest in constructing and using the offshore facilities, various

industry groups, especially those of the petroleum industry having extensive foreign experience, have made independent studies and contributed advice on all aspects of deepwater facilities. Oil industry groups are at present in advanced stages of planning for monobuoy facilities on the Gulf coast and elsewhere.

All of these efforts, together with appropriate inputs from an interagency group of legal experts and from the Council of Economic Advisers, were coordinated in a White House-sponsored study which resulted in the President's recent legislative proposal for Federal licensing of offshore deepwater ports beyond the jurisdiction of the states. The proposed legislation, which emphasizes environmental protection and requires compliance with applicable laws and regulations of adjacent coast states, is consistent with U.S. policies on law of the sea. The construction and operation of deepwater ports with appropriate safeguards is deemed to be a reasonable use of the high seas and not to imply national sovereignty in such areas.

Trans-Alaska Pipeline System

The Trans-Alaska Pipeline System (TAPS) includes a marine leg from Port Valdez, Alaska, to west coast ports, spanning the Gulf of Alaska. Port Valdez, an arm of Prince William Sound, was selected as the northern terminus of the marine leg because, in addition to the requisite deep water, its use is favored by predominantly low winds,



The TAPS marine leg (dark area) is the focus of an important interagency effort to provide environmental information essential to the safe passage of the tankers carrying Alaskan oil to west coast ports.

waves rarely exceeding two feet in height, weak currents, mild temperatures, and no ice cover. The Environmental Protection Agency and the Departments of Commerce, Transportation, and Defense are currently planning augmentation of existing environmental monitoring and forecasting systems, including the use of data received from satellites, supplemented locally by surface observations. The ultimate objective of these efforts, whose purpose is to provide both protection of the environment and aids to navigation, is the establishment of reliable forecasts that will routinely provide information on winds, waves and swell, current velocities, ocean thermal structure, air temperature, fog, precipitation, upwelling, movement of major pressure centers, and ice conditions. The forecasts will be supplemented by warning services to ports and ships as appropriate. These augmented public services will also provide valuable assistance to maritime commerce generally, to the fishing industry, and to the development of possible petroleum reserves in the Gulf of Alaska.

Offshore Petroleum

Geophysical information indicates the existence of favorable geological structures for future discovery of petroleum at many places beneath the U.S. Outer Continental Shelf (OCS). Federal leasing of OCS tracts, which permits exploratory drilling and subsequent production from the favorable structures, has been limited chiefly to the Gulf of Mexico and selected areas off the southern California coast. Altogether the leased areas, which amount to almost 8 million acres, constitute but a small fraction of the total area of the shelf. Of the leases, about one-third are sites of present production, one-third are sites of continuing exploration or development, and one-third have been terminated following failure to find commercially producible reserves. This relatively low level of development is not adequate to meet national needs for domestic production.

Accordingly, the President has directed the Secretary of the Interior to take steps which would triple the annual acreage leased on the OCS by 1979, beginning with expanded sales in 1974 in the Gulf of Mexico and including areas beyond 200 meters in depth under conditions consistent with the President's Ocean Policy statement of May 1970. By 1985, this accelerated leasing rate could increase annual production of hydrocarbons by an estimated 1.5 billion barrels of oil and 5 trillion cubic feet of natural gas.

Legitimate concerns over the threat of environmental damage will continue to control OCS oil development activities. However, new and recently improved technology, new regulations and standards, and new surveillance capabilities enable substantial reduction and control of environmental dangers. The nation should now take advantage of this progress. Plans for OCS leasing beyond the Channel Islands of California will proceed if reviews now under way show that the environmental risks are acceptable. The Council on

Environmental Quality, working with the Environmental Protection Agency and in consultation with the National Academy of Sciences and appropriate Federal agencies, is initiating a study of the environmental impact of oil and gas production on the Atlantic OCS and in the Gulf of Alaska.

The President has asked the Secretary of the Interior to develop a long-term leasing program for all energy resources on public lands, based on a thorough analysis of the nation's energy, environmental, and economic objectives. An outline follows of steps being taken by Interior and other Federal agencies as a part of the Federal Ocean Program applicable to offshore oil and gas development, in cooperation or consultation with State and local governments, industry, and other organizations.

Federal lease tracts in the Gulf of Mexico and off southern California lie adjacent to regions of land and nearshore production. Here the knowledge and experience gained through exploration and development of the onshore and nearshore fields, and the availability of pipeline systems leading to nearby refineries, permit significant production from newly discovered OCS fields within two or three years from the time of leasing. Elsewhere on the shelves, extensive exploratory drilling may be required to confirm the presence of commercially producible reserves. If these efforts are successful, production, pipeline, and other facilities must be constructed. For these regions, industry estimates a time lapse of up to five years from the time of leasing and first discoveries to the attainment of significant production. For remote parts of the continental shelf off northern and western Alaska, where environmental conditions are critical factors, and leasing rules must await completion of CEQ and other studies, the estimated times are somewhat longer. However, the industry's world-wide experience with hostile marine environments, from North Sea storms to Gulf of Mexico hurricanes, will provide much of the engineering design and operating know-how for the Alaskan coastal environment. To these industry estimates, one must add the time required by the government, including the courts, to collect and evaluate independently data that will make promising areas available for leasing to industry and provide sufficient knowledge to assure safety of operations and protection of the environment.

In mid-September and early December, 1972, the Department of the Interior implemented the first two sales of an accelerated lease schedule that was prepared in response to President Nixon's June 1971 Energy Message to Congress. The two sales realized more than \$2.2 billion in bonus bid revenues to the Federal Government, reflecting the petroleum industry's great need for new domestic production. Successful exploratory wells were announced within three or four months of each sale.

The 1972 lease sales and those planned for 1973 are limited to offerings on the Gulf of Mexico shelf, where the promise of early production to meet critical needs is greatest. In anticipation of



An offshore oil-drilling platform is a lonely sentinel in Alaska's Cook Inlet.

(Photo—Courtesy of (API))

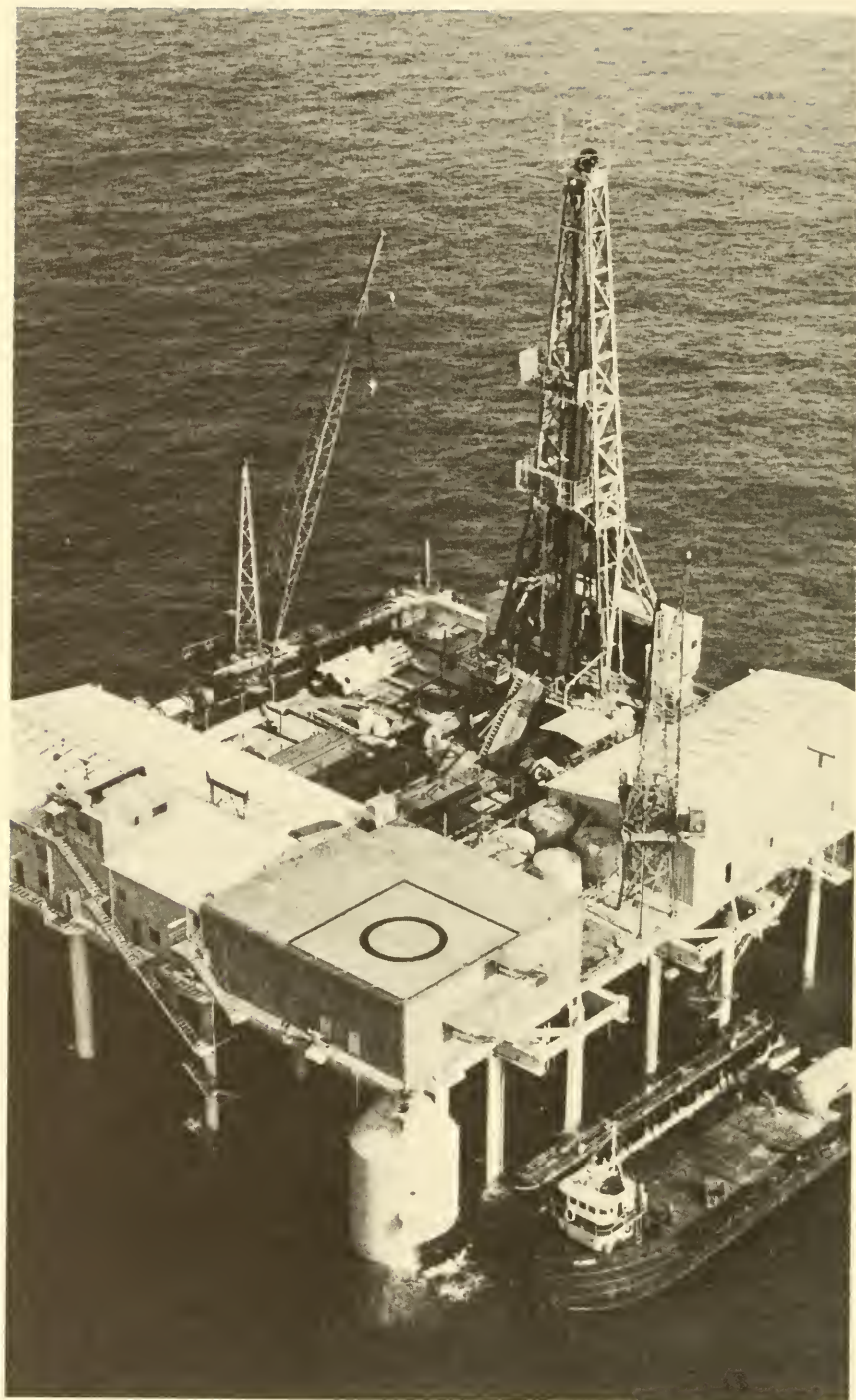
maintaining a higher frequency of sales in this region, the U.S. Geological Survey (USGS) and the Bureau of Land Management (BLM), with the cooperation of industry, are expediting the following programs: identification and assessment of offshore petroleum resource potentials for use in selecting promising oil and gas areas for early leasing, including areas beyond the 200-meter isobath; collection and evaluation of data concerning seafloor and sub-seafloor hazards and associated environmental conditions in the promising areas; planning and conducting lease sales and allocations of pipeline rights-of-way, including preparation and publication of environmental impact statements; and inspection of industry plans and activities to assure maintenance of safe and efficient operations following the lease sales.

Because the number of remaining areas favorable for discovery of oil beneath the Gulf are limited, the USGS is accelerating regional studies of other parts of the U.S. continental shelves to identify and outline promising areas for future petroleum exploration. During FY'72 and FY'73, emphasis has been placed on assembling and synthesizing existing information for the northern half of the shelf along the Atlantic coast and for the shelf bordering the south coast of Alaska. The promising areas identified in these studies serve as focal points for subsequent detailed resource assessments and environmental evaluations.

To identify areas that have promising oil and gas potentials, USGS utilizes proprietary data obtained from industry. Although generally adequate for this purpose, the industry data must be supplemented by other types of information, often gathered for other purposes, to make decisions relating to resource development and to assure safety and protection of the environment during subsequent exploration, development, and exploitation of resources.

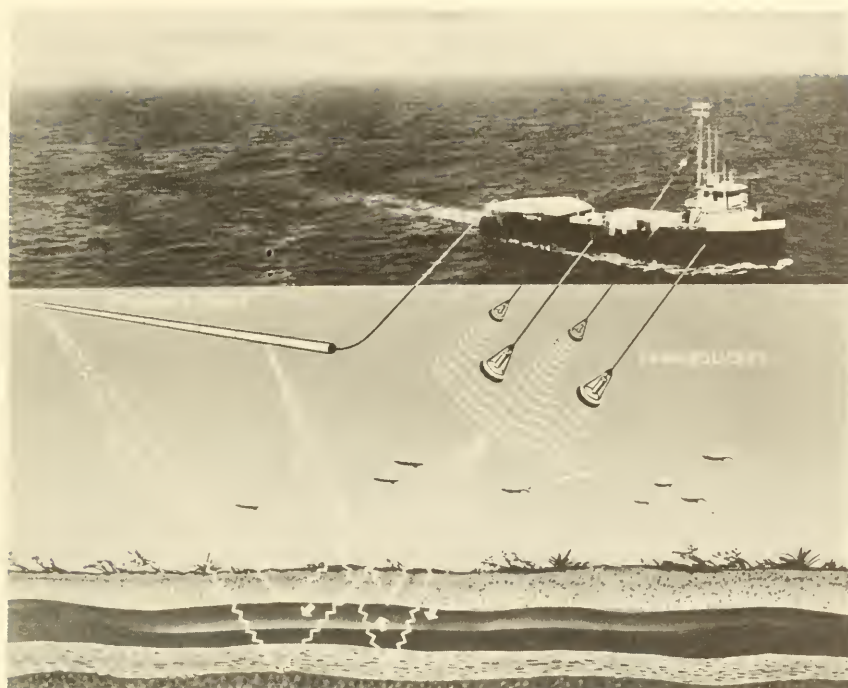
Many agencies participate in the collection and analysis of data for areas that appear to have promise and may be considered for future lease sales. The plans of NOAA's National Ocean Survey for hydrographic surveys include the northern half of the Atlantic continental shelf and the shelf off southern Alaska. These provide basic information on the configuration of the sea floor required for studies of both resource and environmental data. The USGS has accelerated systematic investigations of bottom and subbottom conditions and resources at Georges Bank, an area of high petroleum potential off New England. It expects to initiate similar investigations of a second promising area on the Atlantic OCS off Delaware during 1973. In these same areas, other organizations are gathering information on oceanographic and weather conditions, on fisheries resources, on recreational and transportation uses, and on a variety of other subjects. BLM has begun assembling the information supplied by various agencies and by State and private organizations in order to select specific areas for future leasing and to prepare environmental impact statements for each.

Along the Pacific and Alaskan coasts, the USGS, with the



Mobile semi-submersible drilling rigs such as the *Bluewater III* are used for drilling exploratory wells.

(Armco Steel Corp. Photo—Courtesy of API)



Seismic exploration vessels are used to search for indications of oil and gas deposits beneath the ocean floor. In the system illustrated here, four transducers (sending units) emit signals which bounce off subsurface formations, are picked up by detectors in the streamer cable, and transmitted to the ship for recording and study. Analysis of the data indicates where petroleum may be found.

Continental Oil Company Illustration—Courtesy of API)

cooperation and support of other agencies, has intensified studies and mapping of earthquake belts and other geologic hazards that must be considered throughout large regions in which promising oil and gas structures are expected to exist. Results of these studies supply information that is critical to the determination of pipeline rights-of-way, the planning of offshore installations for power plants, and for other utilization of continental shelf areas, as well as the development of promising oil and gas areas.

Basic and applied research supported by the National Science Foundation (NSF), Navy, NOAA, the Smithsonian Institution, and others supplies large amounts of information that aids industry in its search for petroleum and contributes to related Federal efforts. The NSF's Deep Sea Drilling Program, and the research programs of its International Decade of Oceanography relating to studies of continental margins and the deep ocean floor, have produced a steady flow of data and concepts that help identify areas of resource potential on and beneath the sea floor.



Chapter IV

DESCRIBING AND PREDICTING THE OCEAN ENVIRONMENT

Our knowledge of the ocean environment and its inhabitants has been greatly enriched by the research and exploration of the past decade. The ability to describe, monitor, and predict the flow of energy and matter within the ocean, and the migrations of oceanic life, continues to be a central theme in this national effort. The products of much of this activity are maps and charts, and analyses and forecasts, of conditions in the atmosphere above and in the ocean beneath the air-sea interface, and of the interactions between them. The tools are new platforms, sensors, and other advances in technology applied to observation of the atmosphere and of the oceans and its life, and the mountain of marine environmental data that constant observation must produce. Whatever our use of the marine environment or its resources—whether as a medium of transportation, battlefield, game preserve, source of food or minerals, or playground—the products, and thus the tools, are an absolute condition of success.

Mapping and Charting

Cartographic representations of the ocean basins and their boundaries have long been the traditional way of depicting the sea, and one which has lost none of its importance. But the uses of these products, and the products themselves, have changed. In addition to navigation charts, Federal cartographers are constructing bathymetric and geophysical maps of the sea floor, maps showing inundation levels for low-lying coastal areas, and various types of limited-edition maps for living and non-living resource investigations. These maps and charts must be updated or corrected from time to time, as what they depict is changed by man and nature, or as new data reveals deficiencies. And, as in many other operations, advances in map and chart production lead toward automation—automation from shipboard data acquisition to the finished product.

NOAA's National Ocean Survey Ship *Researcher*—a participant in the Mid-Ocean Dynamics Experiment (MODE).

The Department of Defense produces charts to meet the needs of national defense and provides nautical charts and marine navigational data of overseas areas for the vessels of this and other nations. Last year, in a move to streamline Defense mapping activities, the Defense Mapping Agency was established, and the Navy's responsibilities for preparing marine charting and geodetic products were transferred to the new agency. The Navy still retains the mission and resources for the collection of data and for related basic and applied research for marine charting and geodetics of ocean areas.

The major marine charting and geodesy effort of the Department of Defense is in surveys of the deep ocean. In 1972, 242,000 track miles of data were collected by bathymetric survey ships, and 134,200 track miles by oceanographic survey ships. The level of survey effort is expected to remain the same in 1973 and 1974.

The year saw 94 new charts produced for general navigation, 542 corrected charts published, and 40 new charts reproduced from foreign charts under bilateral agreements. To date there are 26 ratified chart agreements with foreign hydrographic offices. In addition, more than 6,000 maritime safety messages were broadcast. The Defense Department's nautical chart library loaned more than 6,000 charts and received more than 2,500 new ones from domestic and foreign producers. The Department of Defense in 1972 surveyed the coasts of several foreign countries, under bilateral agreement, and the Harbor Survey Assistance Program provided equipment and technical expertise to eight Central and South American nations.

With respect to the technology of chart production, the Navy continued its efforts last year to determine the potential of using methods of data analysis for depth sounding and sub-bottom profiling along non-linear tracks, and completed development of a technique for semi-automatic plotting of shallow-water bottom topography from remote-sensor data. The Defense Mapping Agency is also supporting major development efforts in the use of automated cartography techniques.

NOAA's National Ocean Survey, which charts the waters of the United States and possessions, continued to provide a varied family of cartographic products. Substantial progress was made in 1972 to provide a new data base for nautical charts, bathymetric maps, Coast Guard and Navy requirements, marine environmental quality assessment, ocean engineering, and other studies associated with the development of our continental shelf and adjacent areas.

Last year NOAA's hydrographic survey ships worked off the coasts of Alaska, California, Delaware, Florida, Georgia, Hawaii, Louisiana, Maryland, Massachusetts, Mississippi, New York, Puerto Rico, South Carolina, the Virgin Islands, and Washington. Wire drag operations were conducted in Chesapeake Bay, off the Texas coast, and in Rosario Strait, Washington. In 1973, NOAA

plans hydrographic operations in Alaska, California, Florida, Georgia, Hawaii, Maryland, Mississippi, New York, North and South Carolina, the Virgin Islands, and Washington. Wire-drag surveys will continue in the Gulf of Mexico, southeast Alaska, and around major east coast ports.

During 1972, 9,700 lineal miles of panchromatic, infrared, and color aerial-mapping photography were flown by NOAA aircraft. A total of 217 charts and basic map drawings were corrected using the photographs, which aided compilation of topography for small-craft charts as well as location and verification of 502 navigation aids and 538 landmarks.

At year's end, the Southeastern Coastal Plains Expedition (SCOPE) was begun by the National Ocean Survey. SCOPE is a concentrated two-year environmental study of a 105,000-square-mile area of coastal waters extending from Cape Hatteras, N.C., to the vicinity of Cape Kennedy, Florida, and out to sea as much as 300 miles. The water depths being surveyed range from the surf zone area to 16,000 feet. The study, which combines the resources of NOAA and academic, regional, and State organizations, is designed to provide coastal zone planners with data which should assist in predicting the consequences of both nature's and man's activities in these areas. SCOPE will involve aerial photography of the coastline, surveys of the seabottom topography, charting of coastal waters, tidal current and range surveys, and studies of the sea's physical properties, such as salt content and temperature of the water, and delineation of the Gulf Stream.

Work continues to automate the nautical charting operations of NOAA. Completion of the automation program is projected for the late 1970's, when it is expected that all nautical chart production will be automated, cutting the time from completion of data acquisition to nautical chart dissemination from two years to six months.

As an aid to storm evacuation, NOAA has begun a series of maps showing potential inundation levels along the Atlantic and Gulf coasts where hurricanes may cause flooding. Maps for Galveston and Corpus Christi, Texas, were completed in 1972. Areas to be completed in 1973 include Charleston, South Carolina, Savannah, Georgia, and Norfolk, Virginia.

Geophysical surveys, which describe gravity, geomagnetic, and some geological properties of the ocean bottom and substructure, continued last year in the Departments of Defense, Interior, and Commerce. However, 1972 was the last year of NOAA's marine geophysics program.

Related data collection activities of Navy ships produced 55,000 miles of seismic profile data, 13,000 miles of gravity data, and 342,000 miles of magnetic data. Another 125,000 miles of magnetic data were collected by the new Project MAGNET aircraft using airborne geomagnetic survey equipment. Most of the geophysical data, in addition to its military use, was submitted to NOAA's

Environmental Data Service for storage, handling, and dissemination to interested scientists.

NOAA completed major geophysical data-acquisition projects in two continental shelf areas last year, the Gulf of Alaska and the Oregon-Washington coast. A major deep Pacific Ocean series was also completed. The Geological Survey conducted detailed surveys and analyses of the geological structure of the continental margin.

The Coastal Environment

Even before last year's coastal zone legislation, the Federal Ocean Program had begun to turn shoreward to meet the crucial problems in this area. A magnet for population, the Nation's coastal zone has become home to some 81 million Americans as well as a crowded province of industry, commerce, and recreation. It has been here that the most urgent confrontations between the marine environment and human activities have occurred—confrontations exacerbated year by year as the tempo and tone of conflicting demands on coastal zone land and resources have risen. Thus, some strong coastal zone programs are being developed that are expected to become stronger as the intent of last year's legislation is transformed into programs.

The Environmental Protection Agency (EPA) is presently designing a National Coastal Water Quality Monitoring Network integrating existing capabilities at the Federal, State, and local levels of government. NOAA's National Marine Fisheries Service, working in cooperation with EPA, maintains 190 coastal stations to establish baselines and examine trends in areas where pesticide residues may be accumulating.

Preliminary results from EPA contracts indicate that, of more than 3,000 coastal and Great Lakes public beaches surveyed, some 300 were closed in 1972. In most instances these closings were directly attributable to sewage system breakdowns. The effect of pollution on shellfish-growing areas in the coastal zone was also reviewed by EPA. The results of these surveys will be published as a series of National Ocean Survey charts.

The Department of the Interior's National Water Data Program continued last year to provide multipurpose water data to agencies at all governmental levels responsible for managing, developing, improving, or protecting the coastal environment. In 1972, data on long-term fresh water inflow were obtained at more than 600 gauging stations in the Nation's estuaries, with water quality data available from about 30 stations.

The Naval Civil Engineering Laboratory in 1972 continued development of the Navy Environmental Protection Data Base, which will serve over 240 major naval activities in the continental United States and foreign countries. The pollutants to be monitored will be based upon the results of a two-year pilot program conducted at three representative sites—a naval fleet activity, a naval air

station, and a naval munitions depot. The major aim of the program is to enable the Navy to evaluate the effects of its operation on the environment, as well as the success of pollution-abatement programs. Additionally, the Navy will compile an inventory of appropriate Federal, State, and local laws to insure that its pollution-abatement program meets legislative requirements.

The Corps of Engineers' on-going research into general coastal engineering problems continued. This research supports the Corps' extensive civil works programs and regulatory responsibilities in the coastal zone and on the Outer Continental Shelf. The results are widely disseminated and are extensively used by the private sector, local and State governments, and other Federal agencies as well as the Corps. Consequently, the overall national capability for effective planning, construction, operation and maintenance of essential transportation, recreation, and conservation facilities is considerably enhanced. Current research gives particular attention to wave mechanics, the functional effectiveness and the environmental effects of protective coastal works, the physical and environmental factors which shape and modify the land-sea interface, the dynamics which govern the behavior of tidal inlets and estuaries, and problems unique to harbors in particularly hostile environments such as the Arctic, offshore deep water, and tsunami-threatened areas. Special regional projects continued, such as the San Francisco, Sacramento, and San Joaquin Water Quality Study, the Chesapeake and Delaware Canal Enlargement Study, and the Chesapeake Bay Basin Study.

A national assessment of the shores and beaches of coastal and Great Lakes waters was made available in maps and reports which show shore erosion, ownership and use, shoreline characteristics and erosion effects, and the location of shore parks and protective works. This is part of the National Shoreline Study of the Corps, which has been transmitted to Congress.

Research in coastal zone regions is emphasized in the National Science Foundation's (NSF) Research Applied to National Needs (RANN) program. The RANN program in 1972 included studies of the effects on estuaries of waste discharge and dumping, effects of engineering activities, management strategies for ecologically important areas, and methods for restoring damaged areas. The goal of RANN is to define workable strategies for resolving conflicts between regional growth and development, and environmental quality.

NOAA's Marine Ecosystem Analysis (MESA) program represents a major effort to describe in a systematic way the significant features of marine environmental interrelationships. Significant preplanning was completed in 1972; a full-scale field prototype project is being initiated in the New York Bight in 1973. Provision for needed research in ocean dumping has been made in the New York

Bight project plan. The success of this effort will help to determine the applicability of the program to other critical marine areas.

Estuarine and coastal zone research is being carried out on both coasts and in Alaska with support from the Atomic Energy Commission (AEC). This work includes an environmental study, begun in 1961, to determine the properties, distribution, and movement of Columbia River water and its dissolved and suspended load in the northeast Pacific Ocean.

The marine sciences research program of the AEC is directed toward determining those environmental factors which influence the movement of radioelements through the marine environment, the possible means and rates of return of radioactivity to man through marine food webs, and basic ecological processes. Within this broad program are studies of biological, physical, and chemical oceanography, and studies related to operational activities such as the impact of waste heat from nuclear power stations on the local ecology at such sites.

As nuclear power-plant siting in the estuarine and coastal areas increases, studies must be accelerated on trace-element cycling, modeling of water circulation and sedimentation, productivity at various levels of the food web, and the effects of waste heat and other non-nuclear discharges on the general ecology of the region. Insight into the physical and biological dynamics of the system is essential in order to predict the response of the marine ecosystem to man-induced stresses. During 1972, the AEC continued support for a multidisciplinary study of nuclear power-plant siting in Chesapeake Bay. In 1973, the AEC will accelerate portions of its marine research program toward increasing present understanding of the effects on the marine environment of nuclear power-plant operations. The U.S. Coast Guard, in 1972, collected periodic temperature-salinity-depth profiles at 12 stations on the continental shelf as part of the light-ship/ light-station sampling program. In addition, monthly maps showing sea surface temperature variations and certain biological phenomena were prepared from airborne radiation thermometer coverage of Atlantic and Pacific shelf areas.

Prediction of tides and tidal currents by NOAA's National Ocean Survey is the Nation's oldest marine environmental service. In 1972, 125 permanent tide gauges were in operation along the coasts and within major embayments of the United States, Puerto Rico, and other territories and possessions. The National Ocean Survey also operated 51 permanent water-level gauging stations and 60 to 80 temporary ones in the Great Lakes area last year.

Special tide surveys were conducted along the Florida Coast to define marine boundaries and in the Chesapeake Bay to support the Bay study of the Corps of Engineers. Special circulatory studies were conducted in 1972 along the Massachusetts and South Carolina coasts. The 1973 field season will include tide and tidal current surveys in Port Royal Sound, South Carolina, and circulatory

surveys in Cook Inlet, Alaska, and Mt. Hope Bay, Massachusetts.

The National Oceanic and Atmospheric Administration and its predecessors have operated the Tsunami Warning System as a national service since 1948. The Alaskan Regional Tsunami System, directed from Palmer, Alaska, was established to detect and locate major earthquakes in the Alaskan-Aleutian region and provide information and warnings to people in that region. The Tsunami Information Center in Honolulu, Hawaii, ensures dissemination of tsunami warnings and collects tsunami data on a real-time basis. The detection network of the present Tsunami Warning System is composed of 31 seismic stations and 47 supporting tide stations on the shores and islands of 16 Pacific Ocean countries. The system communicates through the facilities of the Federal Aviation Administration, the Defense Communications Agency, the National Aeronautics and Space Administration, the National Weather Service, and other government agencies, both domestic and foreign. Although no large tsunami occurred in 1972, a tsunami watch was issued after a large earthquake near Taiwan. In July 1972 a regional tsunami warning was issued by Palmer Observatory after a major earthquake near Sitka, Alaska; only a minor tsunami resulted from this seismic disturbance.

Major Research Projects

Last year's Federal Ocean Program noted that the decade of the 1970's would see plans of the previous decade begin to bear fruit in the form of experiments, programs, and valuable data. This prediction has been amply confirmed by the progress achieved in continuing efforts and by the initiation of several promising new programs.

One of the primary goals of the NSF's International Decade of Ocean Exploration is support of research fundamental to improved description and prediction of the marine environment. Knowledge about ocean circulation is critical for predicting the ocean's influence on weather, climate, and pollutant dispersal in the ocean, but detailed understanding of circulation has largely been limited to currents such as the Gulf Stream and the Kuroshio, which follow continental boundaries. The Mid-Ocean Dynamics Experiment (MODE) seeks a more detailed understanding of fluctuations in ocean circulation by combining oceanographic observations with sophisticated numerical theory to establish the dynamics and statistics of medium-sized eddies, their energy sources, and their role in the general circulation of the ocean. The MODE-I field experiment, underway between March and July 1973 just south of Bermuda, involves five United States vessels, the R.R.S. *Discovery* from England's National Institute of Oceanography, and an extensive array of moored instruments.

The North Pacific Experiment (NORPAX) will investigate the



The most recent addition to the academic oceanographic fleet is the University of Miami's *R/V Columbus Iselin*.

influence of the North Pacific on the weather and climate of North America. This has been a matter of scientific speculation for nearly fifty years. During the 1960's the Office of Naval Research (ONR) sponsored research in the North Pacific aimed at identifying the ocean processes linked to unusual weather conditions. Large areas of abnormally hot or cold sea surface temperatures (in terms of 30-year monthly averages) were identified in the North Pacific. Meteorologists and oceanographers postulated that these surface temperature anomalies influenced the atmosphere in a way that affected the climate from the Pacific eastward across the entire North American continent.

In 1972, the IDOE and ONR joined to support research designed to unravel these relationships. The goal of NORPAX is to study and develop a basis for understanding the major physical processes

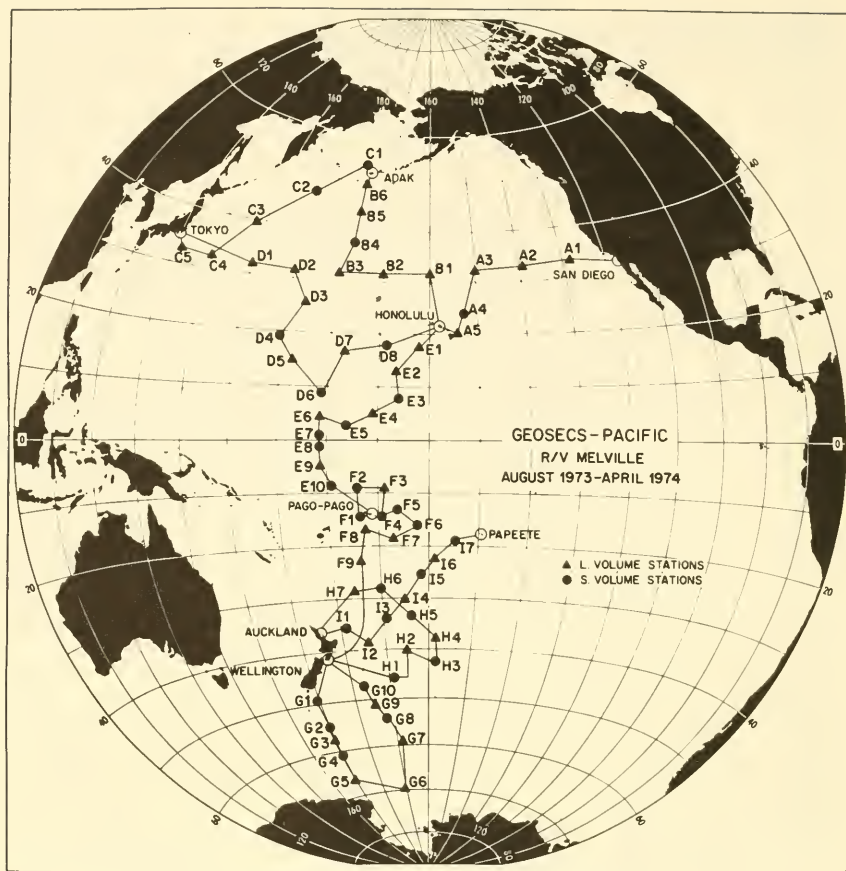
responsible for the large-scale fluctuations in the ocean and atmosphere in the mid-latitudes of the Pacific. Once underway, the NORPAX oceanographic-meteorological observation program will rely on data obtained from oceanographic ships, ships of opportunity, synoptic observations, aircraft, moored and drifting buoys, island stations, and satellites.

Another IDOE project, Climate—Long-Range Investigation, Mapping, and Prediction (CLIMAP), seeks to increase accuracy in environmental prediction by improving our understanding of past climatic conditions. Defining global changes on a continuous time scale for hundreds of thousands of years is important for several reasons. First, it may reveal for the first time the actual series of events during the transition between what are currently considered the two stable states of global climate, the ice age and the temperate age. Second, knowledge of the nature of the transitions is critical for building models of global oceans and climate. Finally, if the mechanisms of natural climate changes are not understood, then it becomes virtually impossible to assess or anticipate the effect of man's activity on the global environment.

CLIMAP researchers, through the study of deep-sea sediments, will examine changes in circulation patterns and water mass properties in the world oceans during the Quaternary, the current geological epoch. The goal of CLIMAP is to determine in detail the surface ocean climatic fluctuations associated with glacial and interglacial transitions. Plans are to make four oceanographic maps showing sea surface temperatures from: (1) 6000 years ago, the warmest post-glacial period; (2) 17,000 years ago, the last glacial stage; (3) 120,000 years ago, the last interglacial period; and (4) 700,000 years ago, the mid-Pleistocene base. Contemporary sea surface maps provide the basis for historical comparisons.

Researchers participating in the Geochemical Ocean Sections Study (GEOSECS) are gathering chemical data on a large number of substances in deep ocean water. These data are essential for determining the rates at which pollutants will mix and diffuse in the deep ocean. GEOSECS scientists are making detailed measurements of oceanic constituents at selected depths along Arctic to Antarctic sections to provide for the first time a set of physical and chemical data measured on the same water samples. In addition to establishing geochemical baselines, these data will provide a basis for quantitative studies of oceanic mixing and for descriptive models of ocean circulation. The Atlantic phase of GEOSECS was completed in March 1973, and the Pacific phase is scheduled to begin in June 1973.

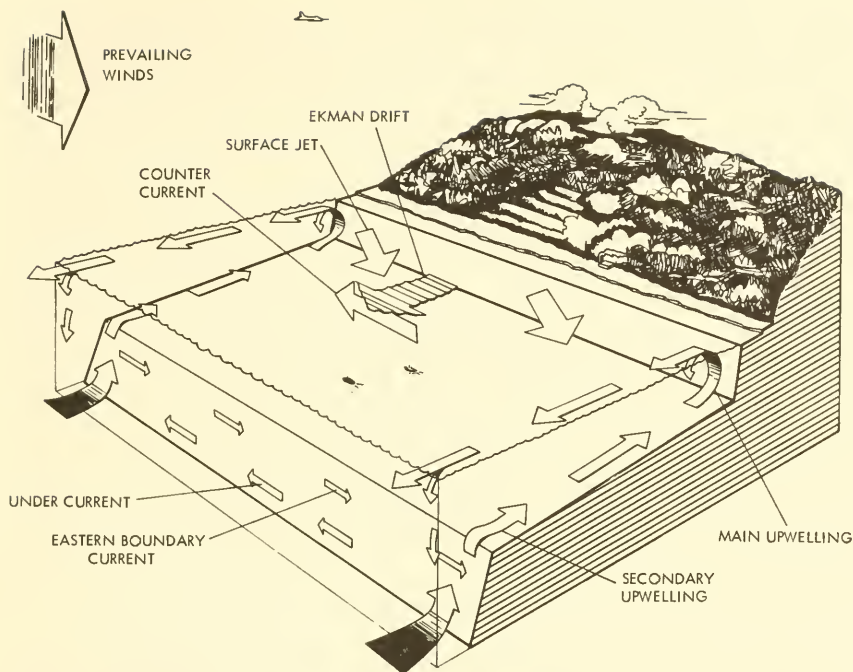
The IDOE is also supporting studies of coastal upwelling. Upwelling occurs when the effects of favorable winds, coupled with those of the earth's rotation, produce an offshore drift of surface layers of the sea along the coast. This induces an upwelling of



Proposed Pacific GEOSECS Cruise Track

nutrient-rich deeper waters to the surface, which results in a rapid growth in the plankton population and subsequently a high level of fish feeding on that food source. An estimated 50 percent of the world's fish supply comes from major upwelling areas. The main objective of the Coastal Upwelling Ecosystems Analysis (CUEA) program is to understand the coastal upwelling ecosystems so that the response of the system to change may be predicted from monitoring a few key biological, oceanographic, or meteorological variables. Field experiments on the physical and biological aspects of upwelling were conducted at two sites off the west coast of North America during 1972. The results of these investigations and the scientific teams involved are providing the basis for a multi-disciplinary investigation of upwelling to be conducted off the coasts of the United States, Africa, and South America during 1973 and 1974.

Under the IDOE Seabed Assessment program, the *Atlantis II* of the



Schematic View of Coastal Upwelling. When favorable winds exist, blowing toward the equator, the earth's rotation produces an offshore Eckman drift of the upper ocean layers along the coast. This drift in turn produces an upwelling of colder, deeper waters near the coast, often a narrow band 10 to 15 km wide. The rich nutrients of the upwelled deeper water cause a rapid growth in the plankton population which results in a rich feeding ground for fish. This phenomenon is significant because an estimated 50 percent of the world's fish supply comes from major upwelling areas.

Woods Hole Oceanographic Institution completed the first half of its survey of the Southeast Atlantic Margin from South Africa to Zaire in 1972. In January 1973, the ship began the second half of this survey, which will be completed later in 1973 with some measurements as far north as Portugal and as far west as the Mid-Atlantic Ridge. These last sets of measurements will enable scientists to tie the results of this survey to those of a complementary survey of the continental margins of the southwest Atlantic off the east coast of South America, which was also initiated in 1972. Scientists from institutions in many European, African, and South American countries participated in both surveys.

Site surveys for the Mid-Atlantic Ridge Study were initiated in 1972, conducted in large part by United States and French institutions, with additional aid from institutions in Canada, the United Kingdom, Iceland, and Portugal. In the Pacific, a comprehensive Nazca Plate survey was launched off the northwest coast of South America. This survey is concentrating on the active margins of the

plate in order to achieve a better understanding of the processes by which ore deposits originate. An international workshop on ferromanganese nodules on the ocean floor was convened under IDOE in New York in January 1972 to assess the present state of our knowledge in this area. As a result of this meeting, substantial quantities of existing data are being compiled for comparison and publication prior to the initiation of new laboratory and field investigations.

In addition, the NSF's Office of Polar Programs supports the Arctic Ice Dynamics Joint Experiment (AIDJEX). Understanding arctic ice and weather conditions is critical for developing the predictive capability necessary for future marine transportation in arctic waters. AIDJEX is a meteorological and oceanographic study of the strength and dynamics of pack ice and the interaction of air and sea in the Arctic Basin. The main goal is to understand the driving effects of wind and ocean currents on the pack ice so that it will be possible to predict the motion and deformation of sea ice into pressure ridges, leads, and large open-water areas. During March and April 1972, the second AIDJEX pilot study was performed on sea ice 300 miles north of Point Barrow. Three manned and five unmanned stations gathered data and allowed evaluation of instruments and techniques that will be used in the main experiment in 1975.

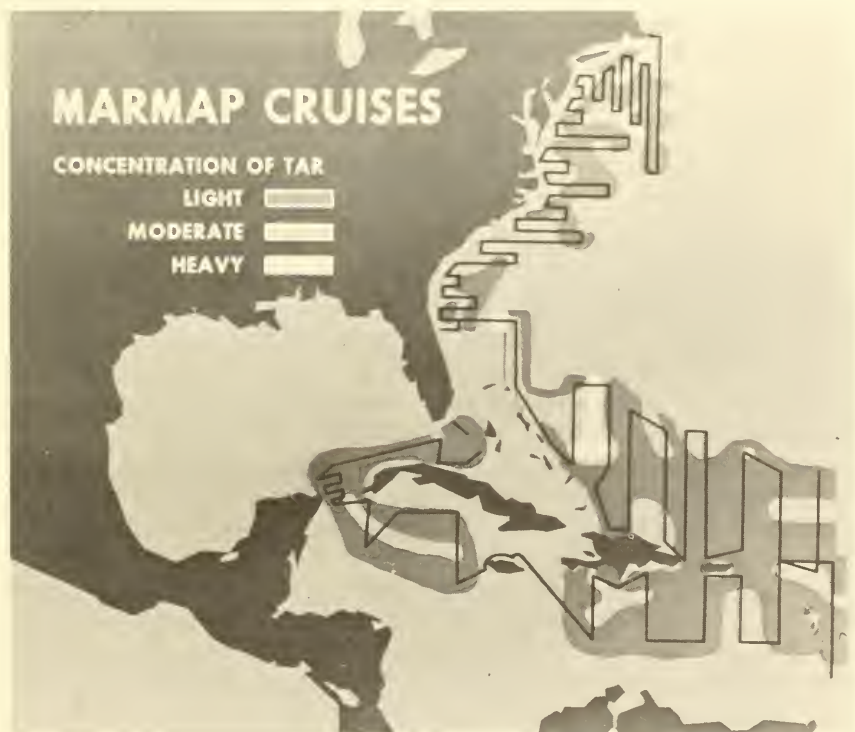
The Deep Sea Drilling Project (DSDP), the major activity of NSF's Ocean Sediment Coring Program, continued last year. Since 1968 the drilling ship *Glomar Challenger* has conducted its history-making expeditions to explore the deep ocean's sediment floor. Leg 28 of the project, conducted over the past year, was the first drilling operation in high latitudes, progressing from Freemantle, Australia, to Christchurch, New Zealand. Analysis of the data indicates that Antarctic glaciation began some 20 million years ago instead of the six or seven million years ago formerly assumed. The ice appears to have reached its maximum extent five or six million years ago, then rapidly receded to its present limits. Other findings were that Australia had broken away from Antarctica some 50 to 55 million years ago. Plans for the coming year include drilling in the western Pacific, then returning to Valparaiso, Chile. The project leaders hope to achieve deeper penetrations of the oceanic crustal structure.

The International Field Year for the Great Lakes (IFYGL), a major cooperative research undertaking of the United States and Canada, completed its field work in and around Lake Ontario during the year and moved into its data-analysis phases. U.S. support for this program is provided by NOAA, EPA, and NSF. A comprehensive international system has been established to process, archive, and disseminate the IFYGL data using two IFYGL Data/Computer Centers, one at the Canadian Centre for Inland Waters in Burlington, Ontario, and other at NOAA's Center for Experiment Design and

Data Analysis in Washington, D.C. These facilities are working with individual investigators to ensure that all data are recorded and available in appropriate forms.

IFYGL data analysis began during the year in eight major areas of study—terrestrial water budget, lake heat balance, water movement, atmospheric water balance, atmospheric boundary layer, evaporation synthesis, lake chemistry and biology, and simulation. Altogether there are 75 American and 81 Canadian tasks. Several models to describe and predict processes occurring in Lake Ontario are under development or test and evaluation. The ultimate aim of IFYGL is to develop an information base and models that will be useful in assessing the environmental impact of various alternatives for developing the resources and controlling pollution of the Great Lakes.

The Marine Resources Monitoring, Assessment, and Prediction program (MARMAP) is a nationally coordinated program of NOAA's National Marine Fisheries Service to monitor, assess, and predict the kinds and quantities of living marine resources available to the people of the United States, and to provide a comprehensive data base for domestic and international management of these re-



The 1972 MARMAP cruises to assess the distribution of fish eggs and larvae found widespread contamination of surface waters by oil residues. Over half of the plankton samples collected in surface layers contained clumps of tar.

sources. To achieve these objectives, fishing catch analysis research of the NMFS will be supplemented by surveys to be conducted for ichthyoplankton, groundfish, and pelagic fish, to determine the spatial and temporal extent of their populations by means of standard sampling methods and data reporting techniques. Environmental groups in NOAA will collate and analyze environmental data for the Atlantic and Pacific with respect to detecting ocean-wide changes in circulation, temperature, water mass, and water type.

In 1972 MARMAP completed much of the planning required for a cohesive national effort, including the program development plan, MARMAP system description, and the Survey I (eggs and larvae) plan. The first multiple-ship test cruises were successfully conducted in the Atlantic from Cape Cod to the Caribbean.

Working relations with other countries were initiated, and by the end of 1972 standardized MARMAP methods of sampling eggs and larvae had been adopted by the Food and Agriculture Organization (FAO) and were being utilized by 20 nations. A cooperative survey by MARMAP and the International Commission for the Northwest Atlantic Fisheries (ICNAF) to determine the magnitude of the herring spawning stocks in the Northwest Atlantic was completed in 1972. Technical advances include the development of a system for automating the sorting of eggs and larvae samples, a shipboard data-logging system, and progress in the development of a new automatic ichthyoplankton and environmental sampling system in cooperation with the United Kingdom.

Data Management

The control and handling of marine environmental data takes several forms in the Federal Ocean Program. Standards are sought and developed to ensure compatibility of results from different oceanographic instruments. The masses of data acquired in the course of the program must be screened for indexing or archival, processed, and disseminated in a variety of useful forms. Where these "data" consist of biological and other specimens, they must be sorted, classified, and, in selected cases, preserved for later study.

NOAA's Environmental Data Service has established a National Geophysical and Solar-Terrestrial Data Center, including a Marine Geology and Geophysics Group. This new group has rapidly developed full working arrangements with the Geological Survey, the Defense Mapping Agency, and the Office of the Oceanographer of the Navy, as well as with NOAA elements and the academic and industrial communities. With NSF (IDOE) support, the group has made significant progress toward developing a true national data service capability with catalogs, indexes, merged formats, and microform services.

The National Climatic Center, (NCC) working closely with the

Naval Weather Service, the Council on Environmental Quality, and the World Meteorological Organization (WMO), has contributed significantly to the global marine climatological information base during 1972 by preparing and publishing baseline references, such as the Environmental Guide for Seven U.S. Ports, Environmental Guide for the U.S. Gulf Coast, and Marine Climatological Summary (WMO Region for USA). NCC is currently archiving national data buoy meteorological data in ship format.

Except for certain water-resources-oriented data on water quality, which are handled by NOAA's National Marine Fisheries Service, the Environmental Protection Agency, and the Geological Survey, NOAA's National Oceanographic Data Center (NODC) has the task of moving the mountain of marine environmental data, and doing it in ways that make it accessible and useful to a wide clientele. The Environmental Data Service, which operates the data center, continues to serve as lead agency for data management and information services for IDOE projects. Last year, NODC acquired the telecommunications hardware necessary to interface its automated Research Program Management System disc to the IDOE office. In 1972, EDS centers (NODC, NCC and the Center for Experimental Design and Data Analysis (CEDDA)) provided a broad spectrum of data flow, archival, and data management services for IFYGL, including the development of an inventory system that describes the various IFYGL data-collection projects.

NODC has developed a system for the Corps of Engineers (COE) to inventory data collected in Chesapeake Bay. A contract between NODC and the Virginia Institute of Marine Sciences has been initiated to provide a more comprehensive supplement to the initial COE inventory for the Bay region.

The Environmental Science Information Center (ESIC) of NOAA is involved in a Selective Distribution Experiment (100 investigators) utilizing the developing Oceanic and Atmospheric Science Information Service (OASIS), an automated, searchable, subject-author-abstract system having great potential for serving the ocean science and technology communities as an adjunct to EDS' Environmental Data Index (ENDEX). ENDEX is, in part, a documented data referral system, fully automated and searchable in an interactive mode. Data file descriptions and documentation are obtained from in-depth interviews by trained contract personnel. Current contract efforts are focused on the Great Lakes, Chesapeake Bay, and the New York Bight.

Internationally, NODC broadened its data-acquisition efforts by establishing or updating bilateral exchange agreements with Australia, Chile, Ecuador, France, Mexico, and Thailand. By an agreement between World Data Center A and the Indian Ocean Biological Center, in Cochin, India, NODC keypunched the second (and final) shipment of zooplankton volumes and taxonomy code

data. Those data will be transferred to magnetic tape and forwarded to the University of Hawaii for analysis and inclusion in an atlas series on the International Indian Ocean Expedition. Acting as the designated Regional Oceanographic Data Center, under the program of Cooperative Investigation of the Caribbean and Adjacent Regions (CICAR), NODC acquired and processed data from Cuba, Mexico, the Netherlands, United States, USSR, and Venezuela, and arranged for completion and publication of *Volume II, Marine Biology*, and *Volume III, Marine Geology and Geophysics*, of the CICAR Bibliography.

Sorting centers operated by the Smithsonian Institution continued to process biological and geological materials for marine scientists throughout the world. The Smithsonian Oceanographic Sorting Center (SOSC) in Washington, D.C. processed over 3.5 million marine organisms in FY '72. Ten percent of these were sent to interested scientists, who were provided with the research services of taxonomic sorting, community analysis, specimen and sample data management, and field logistics. The Center assists various national and international programs in environmental analysis, including the NSF's U.S. Antarctic Research Program (USARP) and NOAA's MARMAP.

Patterned after the SOSC and maintained in Tunisia through the use of P.L. 480 excess currency funds, the Mediterranean Marine Sorting Center (MMSC) processed over 2.5 million specimens in FY '72, primarily from Mediterranean Sea collections. In addition to providing sorting services, the MMSC plays a significant role in the training of technical personnel from developing countries throughout the region. As a result of efforts of the two sorting centers, many marine collections that otherwise might go unnoticed are made available to the scientific community for investigation and documentation in the literature.

The SOSC maintains a computerized inventory of collections received and sorted, and is expanding this inventory to include the data that result from subsequent analysis by specialists. The collections processed and stored by the sorting centers of the Smithsonian constitute baseline information on the current and historical condition of the marine environment.

The sorting centers have capabilities for providing expertise in sampling design and technology, in addition to the processing of samples for both systematic and environmental data. They receive bulk samples from government and private sources, separate them into appropriate taxa for identification by specialists, obtain and coordinate the station data to provide maximum environmental information with the specimens, experiment with preservation, labeling, accessioning, shipping and storage of specimens, train technicians for all aspects of specimen handling, and provide information and data forms which facilitate oceanographic



Smithsonian Oceanographic Sorting Center technician uses a stereomicroscope to examine fishes for key characters in identification.

investigations by insuring that consideration be given to the collection of environmental data. During the past 10 years, over 40 million specimens have been processed by the Smithsonian's two centers, which provide international leadership in this field.

The National Museum of Natural History (NMNH) of the Smithsonian Institution maintains the world's largest collection of biological specimens and geological samples. These collections constitute an important resource for studies on current and historical environmental conditions and are actively being studied by scientists from the Museum and elsewhere. In most cases, collections such as these are the only biological and geological record of past environmental conditions for a large part of the marine environment.

In addition to serving as baseline information on the distribution and abundance of biological populations and geological strata, museum specimens are used to determine the historical condition of certain environmental parameters. For example, general environmental conditions such as temperature and salinity frequently affect the growth patterns of certain organisms. Selected marine specimens can therefore be examined to determine existing conditions at the time and place of collection. In addition, marine organisms often accumulate in their internal structures dissolved inorganic and organic chemicals from the surrounding waters. Under a grant from the IDOE, an exploratory program has been initiated by the NMNH for analyses of toxic heavy metals (Hg, Cd, As, Zr, Cu, and Pb) in museum-preserved specimens. The use of museum collections for baseline studies of trace elements in the marine environment increases their inherent value as indicators of past environmental conditions.

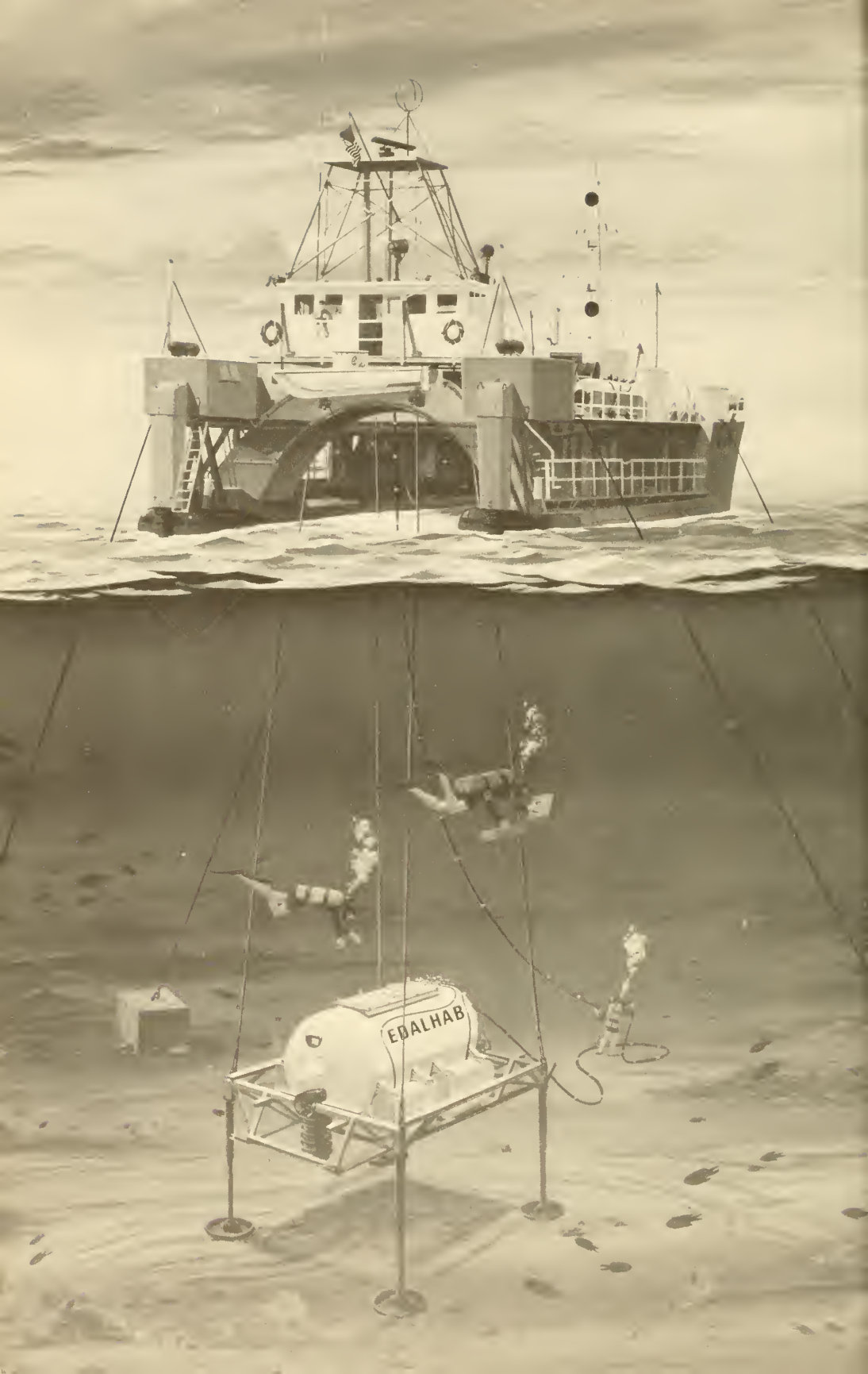
Other relevant information is obtained from museum collections in the determination of the trophic composition of "communities" of organisms. Biotic indices such as "species diversity" give useful information regarding short-term environmental stresses and long-term ecosystem stability. In this way, biological samples that are collected at a certain specified time and place serve as "time-capsules" of ecological information. This information attains maximum usefulness when accompanied by other environmental measurements taken concurrently with the biological samples.

The use of museum collections for marine environmental baseline purposes depends in large part on the rapid retrieval of information relative to taxonomic categories, time and place of collection, and associated chemical and physical environmental data. Through continuing and expanding use of automatic data processing (ADP), the routine chores associated with cataloging collections are becoming less of a burden, and ADP is being used to a greater degree as a research tool in the museum. At present, ADP techniques are being applied to crustaceans, echinoderms, and several groups of

mollusks. Data on the marine mammal collections in NMNH as well as those at the Field Museum of Natural History in Chicago and the Museum of Natural History at the University of Kansas were recorded for computer storage as a first step in providing a comprehensive computer-based catalogue of all collections of living marine mammals.

Instrumentation

NOAA's National Oceanographic Instrumentation Center (NOIC) in Washington, D.C., provides the marine sciences community with the means of testing and evaluating new instruments and calibrating operational instruments, both under laboratory conditions and conditions which simulate the harsh environment of the sea. Between January 1970 and September 1972, the Center evaluated and reported on 30 new oceanographic instruments, and calibrated thousands of thermometers and other pieces of test equipment. To become more responsive to the need for calibration of oceanographic instruments, it has established regional centers in Seattle, Washington, San Diego, California, and Bay St. Louis, Mississippi. These regional facilities provide test and evaluation capabilities where they are most needed, and at the same time reduce the expense and hazard of shipping delicate equipment.



Chapter V

TECHNOLOGY FOR UNDERSEA OPERATIONS

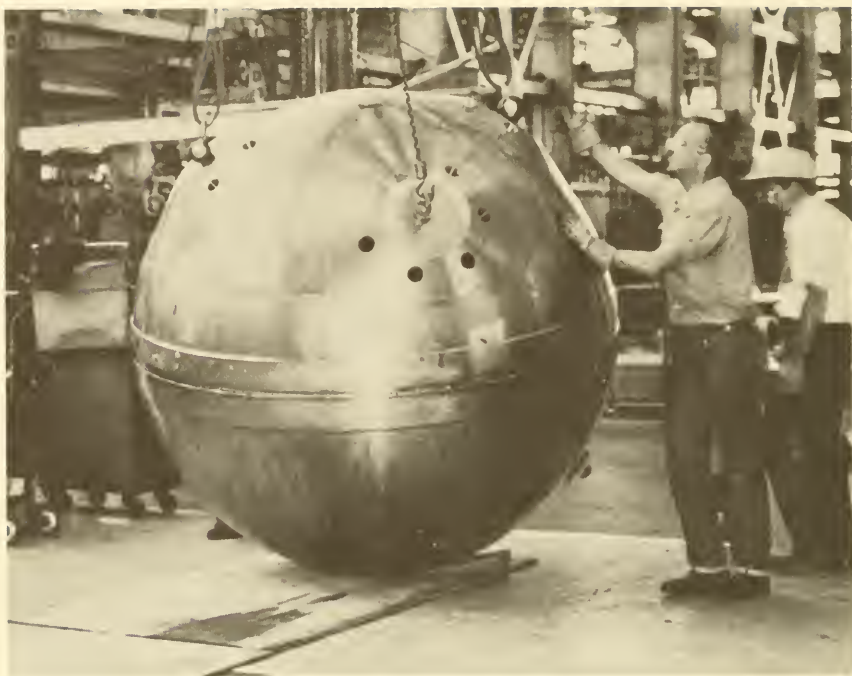
The rapidly developing ability to observe the ocean and its life from the surface, the atmosphere, and space is being matched by important advances in man's ability to observe the undersea world from within. No instrument or automated system can match the performance of a trained human observer, and it is natural that, as the Federal Ocean Program matured technologically, a strong effort would begin to extend man's ability to explore, inhabit, and work in the difficult underwater environment. The thrust of the projects conducted toward these ends has been to provide materiel and tools that can get men safely into the sea, sustain them there, and remove them safely, armed with the instruments they need to achieve their undersea objectives. The transfer of technology in these areas from military to civil efforts has been quite effective, and today the Navy, NOAA, other Federal and academic institutions, and industry share an active research and development program in this area.

New Materials and Equipment

Before man can extend his time and depth limits in the sea, he must design improved materials and equipment that can function successfully and safely under the new stresses to which they will be subjected. The development and use of such materials is one of the objectives of the Navy's ocean engineering program. This program, in addition to satisfying Navy requirements, is perhaps the major source of technical development for civil ocean requirements.

One Navy project to advance the depth limit of undersea exploration was the construction of a titanium-alloy hull for installation on the deep submersible, *Alvin*. Not only will this material double *Alvin*'s working depth to 12,000 feet, but it will also reduce its weight and increase the payload carried by the vehicle. In March 1972, the Naval Ship Research and Development Center,

Artist's conception of Navy-sponsored catamaran *Lulu* serving as support ship for the under sea habitat EDALHAB in 1972 Florida Aquanaut Research Expedition (FLARE).



This new titanium sphere will extend the *Alvin*'s working depth to 12,000 feet.



SEACON I concrete structure after 11 months exposure at a depth of 600 feet.

Carderock, Maryland, successfully tested the hull in a pressurized oil bath to the equivalent of 13,000 feet in depth. Alvin's new hull will be tested at sea in mid-1973.

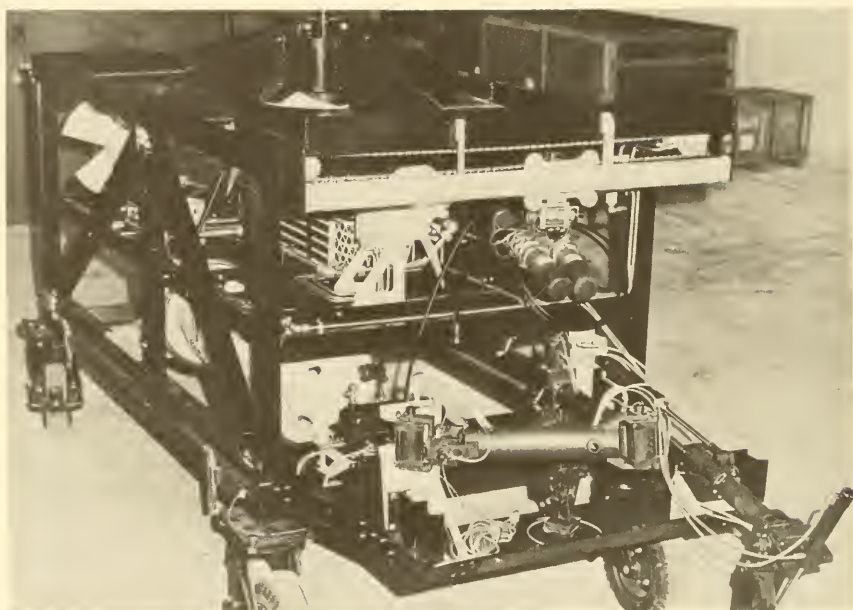
A continuing program to improve methods of providing buoyancy for submerged systems has resulted in the use of solid, lightweight syntactic foams. The foams are long-lived and neither flammable nor subject to permeation by seawater. Currently, a great deal of effort is being made to improve the foams by reducing their density and by developing techniques by which large quantities can be produced relatively inexpensively.

The Sea Construction (SEACON I) experiment, conducted off Santa Barbara, California, is designed to evaluate concrete for seafloor construction and to provide a facility for testing hatch and viewport designs as well as antifouling techniques. One cylinder and 18 spheres of precast concrete are used in the experiment. In January 1972, after eleven months' submergence, the experimental cylinder was raised from a depth of 600 feet. Monitoring sensors within the cylinder provided information on stress, strain, seawater permeability, and internal atmosphere (dust, humidity, oxygen, etc.). The concrete spheres are still anchored near the bottom at graduated depths from 2,000 to 5,000 feet. SEACON II, an eighteen-month sea-construction demonstration, will begin in October 1973 with the installation of a seafloor platform, cable structures, and other equipment, much of which is in the final stages of development.

A new type of deep-ocean corer is being fabricated to take 50-foot bottom cores at depths of 6,000 feet. Unlike other corers, this device will not disturb or rearrange the bottom sample. Engineering analysis of the samples will be correlated with less direct electronic analysis of the seafloor to determine its weight-supporting ability and other engineering properties, knowledge of which is necessary for the installation of bottom structures.

Anchors and cables are being developed to hold subsurface and bottom structures in place. A vibratory embedment anchor, which uses an electric motor to drive the anchor into the sea floor, has been demonstrated. The anchor can hold 50 times its own weight at 6,000 foot depths. An explosive embedment anchor, which is driven into the sea floor by an explosive charge, is also under development. At a 20,000 foot depth, it will hold against a 20,000 pound pull.

Cables are being developed to moor platforms to these anchors and to control unmanned underwater work systems. New resin materials are being investigated for use in durable, light-weight cables that are neutrally buoyant and of high strength. These cables will be used to support the Remote Unmanned Work System, RUWS-20, at 20,000 foot depths. The vehicle and other system components have been completed and will be assembled next year. Four miles of cable will be used in RUWS operations. Because of the cable's neutral buoyancy, the RUWS vehicle will be able to move without the use of additional power or flotation.



The Navy's Remote Unmanned Works System (RUWS), shown in assembly, will be able to perform a variety of engineering and scientific tasks both on the deep ocean floor and in the water column above.

Connectors to couple electrical cables to underwater facilities or instruments are being developed. These connectors are metal-pronged plugs and watertight rubber sockets which will handle 360-kilowatt loads and can be coupled or uncoupled by divers at shallow depths or by submersible system manipulators down to 6,000-foot depths. The development of other power equipment, a pressure-compensated sea-floor battery charger and batteries capable of multiple recharging under pressure, was completed in 1972.

Launch and Recovery Systems

Another technological area has come into existence aimed at improving the methods of placing men and equipment into the sea and retrieving them from it. This program has focused mainly on three crucial problems: deployment of submersible platforms from shipboard cranes, submarines, and semi-submerged ships; salvage of large objects; and retrieval of emplaced items.

A motion-compensating shipboard crane for installation of large ocean bottom facilities is now being field tested. By automatically compensating for ship motion, it keeps the object on the end of its cable from surging up and down. The shipboard crane will be used in SEACON II to place 20-ton structures carefully at predetermined sites on the sea floor, 6,000 feet below, while the surface ship rolls in response to waves up to 8 feet.

Because of their limited range, manned submersibles are carried to their launch sites by mother ships. For instance, the Deep Submergence Rescue Vehicle (DSRV) is carried by a catamaran submarine rescue vessel or by a mother submarine. The catamaran launches the DSRV by lowering the vehicle between the catamaran's two hulls. The vehicle is thus protected from the hazards of wind and wave during launch. In the principal method, the mother submarine carries the DSRV on the after deck. To launch the vehicle, the submarine surmerges, and the DSRV is uncoupled and swims away. Because the DSRV is launched underwater, it is protected from both wind and wave during this critical period. It may also be so launched under ice. Two DSRV's, capable of deployment from catamarans or submarines, will be in limited service for 5000 foot underwater rescue operations by December 1973 and in full service by July 1974. Another type of launch platform, a semi-submerged ship, is under construction. It consists of two cylindrical hulls connected by pylons to a platform above. Because its hulls will be submerged and thus not susceptible to surface wave action, the vessel will remain relatively stable during launch and recovery operations. This ship can serve as the tender for the RUWS.

Conventional underwater salvage systems require divers to tunnel under sunken ships to secure lifting chains around the hull. In this method, there is always the danger of diver entrapment beneath the hull by a tunnel cave-in or backfill. The Large Object Salvage System (LOSS), now under development, will carry out salvage operations without divers. The principal unit of the LOSS system is a self-positioning, underwater pontoon that can lift 100 tons. By using several pontoons hooked together, the system will be able to lift aircraft or submarines from depths of 1,000 feet. The LOSS pontoon is controlled via cable from a command center aboard a surface support ship. The pontoon will carry articulated attachment arms, explosive pins that can be secured to the wreck, buoyancy generating systems, and sensors.

Acoustic Navigation Systems

To accomplish useful work in the sea, man must be able to locate objects and remain at or return safely to a given spot with a minimum expenditure of time and effort. Because sound propagates in water with less attenuation than any other known energy form, the need for accurate, deep ocean navigation is being met through the use of acoustics.

There are problems, however, which must be considered in the use of present-day acoustic systems. An underwater object cannot be acoustically located if hidden behind an underwater ridge. The sound waves will either be blocked by the ridge or will bounce off the jagged surface of the ridge several times, resulting in a confusion of sound echoes. To overcome the problems of sound wave blocking

and reverberation, the Advanced Research Projects Agency of the Department of Defense is sponsoring an effort at the Woods Hole Oceanographic Institution to improve manned submersible navigation by bounding sound signals off the ocean surface and hence over the intervening ridge.

In another research effort, the Naval Undersea Center is developing computerized integration and display techniques for the visual representation of acoustic signals. These techniques will present the submersible operator with a geographically oriented navigational picture. It is expected that by 1975 these techniques, combined with the surface-bounce navigation system, will be utilized on the RUWS and the *Alvin*.

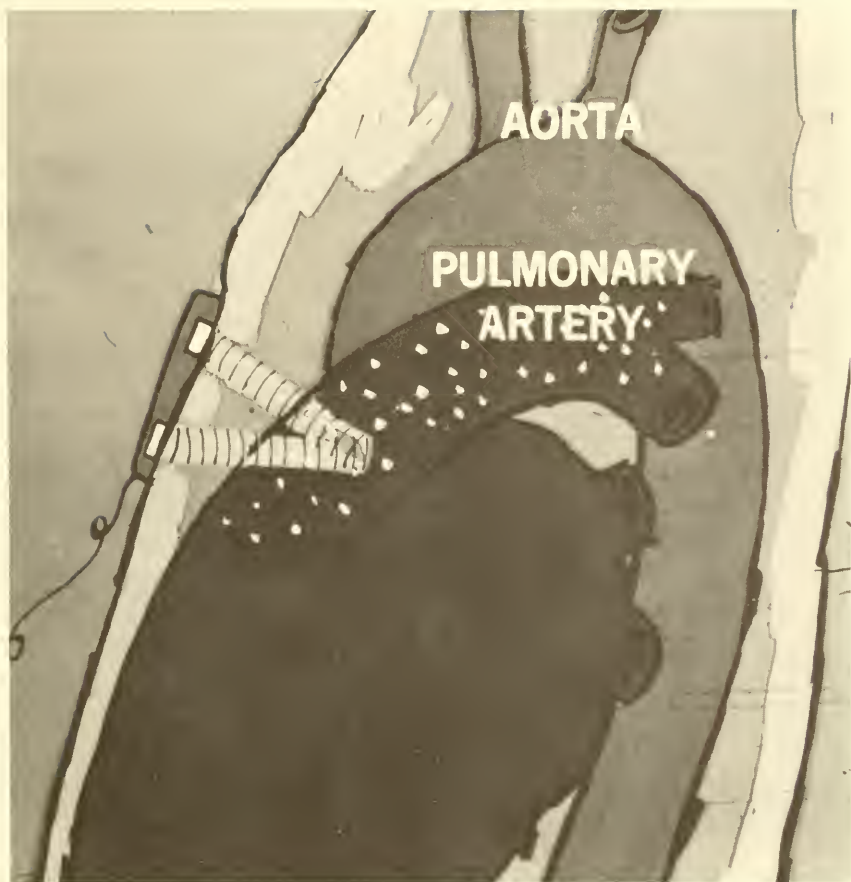
Productive utilization of deep submersible vehicles requires operations in waters of low visibility and high turbidity where optical systems are severely constrained. Improved optical systems result in only slight gains in such environments. To overcome this critical operational constraint, a real-time, high-resolution acoustic imaging system is being developed under contract. This system, utilizing acoustic holography with computer reconstruction of the image, will provide a distinct image to 100 feet. It will be constructed for installation on the Navy submersibles *Sea Cliff* and *Turtle*. Delivery of the system is expected in January 1974. All three acoustic navigation systems could be used on civilian-operated undersea vehicles such as those for monitoring or repairing underwater oil rigs, or by submarine oil carriers which have been suggested for ice-covered waters.

Research to Support Diver Operations

To provide knowledge and safety guidelines to benefit the diver, work is underway on a new civilian diving manual, the collection of data on the effects of shorter decompression after saturation diving, and on long-term health problems resulting from exposure to underwater pressure. The development of a civilian diving manual, being prepared by NOAA primarily for scientific and working divers on NOAA-sponsored projects, will be completed in mid-1973. Data from the U.S. Navy, universities, and industry are being reviewed and integrated into the manual wherever applicable.

A NOAA effort is examining new safe vertical excursion limits for divers saturated at various depths with nitrogen-oxygen breathing mixtures. This research promises to open new vertical depth range capabilities without increased decompression to permit more flexible diving from ocean floor laboratories on the continental shelf. Vertical excursions with no decompression, simulated in hyperbaric chamber tests, have thus far been free of decompression sickness and nitrogen narcosis at greater depths and for longer durations than previously thought possible on nitrogen-oxygen breathing mixtures.

The Navy has applied acoustic technology in its Doppler bubble



This sketch of the Navy's new Doppler bubble detector shows the projection of sound signals into the pulmonary artery. The quality of the signals reflected back indicates the presence of bubbles.

detector, a device for early detection of gases coming out of solution from a diver's bloodstream. The instrument is placed on the diver's chest and projects a sound signal into the main artery of the lung. A gas bubble can be detected because it produces a reflected signal different from those produced by blood fluid. With further development of this device, it may be possible to tailor reduced decompression times to individual diver physiological characteristics. NOAA divers have used this detector during the vertical excursion studies mentioned above.

In another coordinated NOAA/Navy program being pursued at the U.S. Navy's Bureau of Medicine and Surgery, substantial progress is being made in understanding the physiological stresses of long exposure to intense pressure, particularly those involving the little-understood phenomenon of bone degradation (aseptic bone

necrosis). The possibility of ear function damage is also under investigation.

"Hard-hat" diving gear, although heavy and cumbersome, offers the diver an unlimited air supply, thus permitting him to perform arduous underwater work for relatively long periods of time. The Navy is currently developing a new "hard-hat" helmet and suit that is lighter and safer than those presently in use. This diver outfit will be tested in the fall of 1973.

Submersible Operator Aids

New control systems and work tools are increasing the capabilities of submersible operators. Operators now have devices to control the machines fastened to the hulls of submersibles without the safety hazard of wires going through the hull. For example, a recently developed electro-magnetic coupling device has transmitted information through a submersible hull. In another experiment, light signals have been coupled through the acrylic hull of the Navy's deep submersible, *Makakai*, transmitting command and control information to the trim and propulsion system.

A modular system package is being developed to upgrade the capabilities of the operators of Navy deep submergence vehicles and cable controlled platforms. This system incorporates several work functions consisting of rugged, highly reliable, mechanical hands that move six ways, heavy duty vises, power tools, and a winch system. It will have the capability to manipulate and hold 2,000 pound articles. The modular package is being designed for installation on the Navy's CURV, *Sea Cliff*, DSRV, NR-1, *Dolphin*, and *Trieste*, as well as the RUWS.

Manned Undersea Activities

As each new concept in undersea technology is proven, its application increases the effectiveness of support for other programs. A major element of this effort is provided by NOAA, which, through its Manned Undersea Science and Technology (MUS&T) Office, continues its role in support of civilian operational capabilities for man to work under the sea in support of programs whose aim is to achieve a better understanding, assessment, and use of the marine environment and its resources.

Emphasis has been placed on conducting and coordinating ongoing manned undersea scientific research programs and on providing the supporting technology necessary for safe and expeditious fulfillment of such activities. MUS&T maintains a continuing survey and assessment of undersea vehicles and platforms developed by industry and the Navy, and maintains close liaison with the Navy to provide transfer of technology from military to civil applications. MUS&T is also coordinating the use of the



Coast Guard divers used a submersible in a Bering Sea walrus study sponsored by NOAA, the National Science Foundation, and Navy.

available undersea platforms for scientific projects jointly sponsored by NOAA and other Federal agencies including the Navy, Coast Guard, National Science Foundation, and Environmental Protection Agency. This effort is part of its role in the continuing assessment of the Federal civilian agency needs for submersibles and habitats, and the coordination of the use of available commercial and Navy assets by the civilian Federal agencies as recommended by the Interagency Committee on Marine Science and Engineering (ICMSE).

MUS&T projects support coastal zone conservation and management efforts, the survey and assessment of resources, assessment of ocean dumping and environmental pollution problems, and marine ecological studies. From September 1971 through December 1972, twelve operational projects were conducted on all three coasts of the United States, the Bahama Islands, the Bering Sea, Belize, and Puerto Rico. These projects involved the



As part of Project FLARE, a NOAA scientist emplaces a light sensitive instrument to measure the energy available to reef populations. Simultaneous measurements of respiration and photosynthesis provides an index of the impact of pollutants.

participation of over 240 scientists, the use of eight submersibles for more than 260 dives, and the use of three ocean-floor habitat/laboratories, from which divers made over 740 excursions to perform specific mission-oriented tasks. Over 80 percent of the participants represented universities, industry, and federal agencies other than NOAA.

In the New York Bight, knowledge of the movement of bottom sediments along the continental shelf is important to decisions on the location of offshore dump sites. In the first phase of a two-phase project, scientists making observations from the Perry Submersible Corporation's PC-8 concluded that the nearshore bottom topography was being altered by present-day currents and that the currents would affect the movement of dumped pollutants. In phase two, scientists using the *Deepstar-2000* submersible in deep water found that a proposed dumpsite had a greater population of fauna than had been anticipated from surface sampling. Another effort, in the Hudson Canyon off New York, employed the *Alvin* submersible at depths down to 6,000 feet. The study concluded that the canyon appears to serve as a "pipeline" for fine-grained sediment transport from the continental shelf out to deeper depths.

In the Florida Aquanaut Research Expedition (FLARE), a small, transportable habitat, EDALHAB, was deployed from the Navy-funded research vessel *Lulu* at four different locations off the southeast coast of Florida. Divers conducted experiments that led support to the concept that living coral reef communities can be used as environmental indicators. This project was the first to use a transportable habitat.

The Southern California Borderlands project used the *Deep Quest* submersible, in depths ranging from 2,700 to 6,700 feet, at a site where ocean dumping had been permitted for over 25 years. Inspection of a dumping site used for radioactive waste 11 years ago showed radioactive waste containers still intact with no sign of deterioration or leakage. Additionally, a potential ocean dumping site in a deep canyon off San Diego was inspected to determine sediment flow and waste dispersal. Tight canyon meanders were found to limit flow processes. Studies of environmental conditions and trends, as well as of the impact of ocean dumping on the coastal area, are being planned for this region in the near future.

In a joint NOAA/National Science Foundation project conducted off the coast of Belize, selected portions of a living reef structure were blasted away to study the formation processes of reefs and their correlation with the characteristics of ancient oil-bearing reefs.

In December 1972, NOAA and the Navy participated in a joint US-Canadian diving project using the SUBIGLOO underwater habitat 40 feet under the Arctic icepack of Resolute Bay, Canada, to evaluate the performance capabilities of divers and their equipment in Arctic waters.



The Bahama Banks Research Program, using divers operating in a saturation mode from a small habitat, HYDROLAB, is continuing operations started over a year ago. Environmental data are being collected on reef ecosystems to formulate a new methodology for measuring the effects of coastal pollution on living reefs and for establishing indicators for the assessment of environmental health.

Efforts have started on the three-year French-American Mid-Ocean Undersea Study (FAMOUS) to make a detailed investigation of the Mid-Atlantic Ridge in an area some 200 miles south of the Azores. This study is expected to furnish direct knowledge of how the earth's continents and oceans were formed, and provide information that bears directly on the formation of ore deposits. Study of ridge structural relationships may also provide information on the formation of continental structures capable of trapping oil.

In 1974, the French bathyscape *Archimede*, French submersible SP-300, and the American submersible *Alvin* will carry out some 40 dives to depths of 12,000 feet, with special missions for each submersible, including detailed mapping, bottom sampling, and instrument emplacement and retrieval. These will be the most extensive manned submersible operations yet to be undertaken in the deep ocean. The United States effort is being supported by the Navy, the National Science Foundation, and by NOAA, the lead American agency in overall U.S.-French cooperation in oceanography. The French effort is led by the Centre National pour l'Exploitation des Oceans.



Chapter VI

NEW SYSTEMS FOR OCEAN OBSERVATION

The year 1972 was notable as a period in which new generations of sensors and platforms began arriving in the form of operational systems and engineering prototypes. Of particular significance was the appearance of NOAA-2, an advanced satellite in the operational polar-orbiting series that carries greatly improved visible and infrared sensors, and that supports a greatly extended family of "wet" data products, and of engineering prototypes of several configurations of ocean data buoys. At the same time, remote sensing of oceanic parameters made significant advances as scientists improved their ability to see the marine environment through the "colored glass" of infrared, microwave, visible, and other regions of the electromagnetic energy spectrum.

Data Buoys

On the first day of February 1973, a 100-ton experimental data-reporting buoy marked up the third anniversary of its anchoring in the Atlantic Ocean, where it has been keeping tabs on ocean-spawned storms which could endanger the mid-Atlantic states and New England. In doing so, it established a record for longevity in the deep sea for a buoy of such size. The device is the first of a series of giant experimental environmental data reporting buoys being developed and tested by NOAA. Similar experimental buoys are reporting data from the Gulf of Mexico and the Gulf of Alaska, where they were anchored last year by the Coast Guard for NOAA's Data Buoy Office. The Office is located at the Mississippi Test Facility of the National Aeronautics and Space Administration (NASA) at Bay St. Louis, Mississippi.

The Atlantic buoy is anchored on the western boundary of the Gulf Stream approximately 125 nautical miles southeast of Norfolk, Virginia, in 9900 feet of water. The buoy was deployed February 1, 1970, and since that time has been overhauled, refurbished, and

Satellite observations may be used to monitor sources of water pollution. This image, made by a multi-spectral scanner on the Earth Resources Technology Satellite, shows S-shaped pattern resulting from the dumping of sewage sludge from tug-towed barges just outside New York Harbor.

refitted with new and improved components and sensors. The buoy, originally developed for the Office of Naval Research, was transferred to the Coast Guard and then to the Data Buoy Office, when that group was formed within NOAA's National Ocean Survey to develop a national system of environmental data reporting buoys.

The Atlantic buoy (designated EB-01 for Environmental Buoy Number 1) has already made noteworthy contributions to the weather watch along the densely-populated east coast. In the three-year period in which it has been functioning, the buoy has been one of the prime sources of data which revealed the formation of more than 50 major storms off the mid-Atlantic and New England coasts. The data from the buoy contributed significantly to more accurate and timely predictions of heavy snowfalls, flooding rains, high winds and seas, and destructive tides and storm surges, with a resultant savings in life and property, business, and transportation.

Originally, the buoy was instrumented with meteorological, limited oceanographic, and engineering sensors, an on-board computer system, power supply, and, for self-preservation, radar reflectors and navigational lights. As refitted, the buoy's instrumentation now monitors solar radiation, precipitation rate, air temperature and pressure, dew point, wind speed and direction, surface water temperature and current velocity, and wave motion.

The buoy is programmed to check all its sensors once per hour, record the data, and transmit them every three hours to the Coast Guard Radio Station, Miami, Florida. They are then sent to NOAA's National Meteorological Center, Suitland, Maryland, and finally to other users via regular weather networks. The buoy is capable of more frequent interrogation on request when needed for critical monitoring periods.

Experience gained from the Atlantic buoy has contributed to the development of the buoys anchored in the Gulf of Mexico and the Gulf of Alaska. The EB-10 buoy in the Gulf of Mexico, located about 225 miles southeast of Bay St. Louis, Mississippi, has been periodically reporting environmental data since it was anchored in June 1972.

This massive buoy is designed to withstand severe weather and sea conditions, including 150-knot hurricane winds, 60-foot waves, and 10-knot currents. Its platform carries meteorological sensor packages at levels of 15 and 30 feet, and a hull-mounted oceanographic sensor package. It will eventually be fitted with 12 oceanographic sensor packages at various levels down to 1500 feet.

The buoy in the Gulf of Alaska (EB-03), deployed in the sub-Arctic waters in October 1972, is similar in design to the EB-10. Its stationing in the Gulf of Alaska is providing an on-site test of the ability of the experimental buoys to withstand particularly severe environmental conditions. Meteorological information transmitted by this buoy aids weather forecasting for Alaska and the west coast



The EB-10 buoy was towed out to its operating station in the Gulf of Mexico by the Coast Guard cutter *Acushnet* in the summer of 1972.

of North America, and will be used in support of the Northern Pacific Experiment (NORPAX) under the sponsorship of the Office of Naval Research and the National Science Foundation.

Two types of smaller, limited-capability buoys are also being tested, one type designed to be moored, the other to drift freely. The power capacity, sensor complement, and operational lifetime of these buoys is less than that of the large buoys. A "minimum-capability" buoy which can carry a small number of sensors to measure several key parameters is also under development.

Six experimental spar buoys, designed specifically for operation in the polar region, were field-tested during the spring of 1972 in conjunction with the Arctic Ice Dynamics Joint Experiment (AIDJEX) pilot project in the Beaufort Sea, under the sponsorship of NSF's Office of Polar Programs. These buoys were emplaced in holes cut in the sea ice, each buoy carrying a complement of meteorological sensors and a NASA position-location data-relay transponder package designed to work with the Interrogation, Recording, and Location System (IRLS) on the Nimbus-4 satellite. The IRLS system has demonstrated not only the feasibility of collecting environmental data from sensors on buoys deployed in the harsh and extremely remote areas of the Arctic Ocean, but also its utility in providing information on the dynamics of the polar ice through daily updates in the relative positions of the array of buoys. Four of the buoys operated satisfactorily for more than a year. Subsequent to the successful completion of the arctic data buoy experiment, NASA



This Experimental spar buoy was emplaced in sea-ice for field testing during the Arctic Ice Dynamics Joint Experiment (AIDJEX). In addition to proving their utility, these buoys relayed highly useful environmental information to a satellite above.

acted on a request from NOAA's National Weather Service to interrogate one of these buoys on a daily basis to obtain operational weather forecasts for the Alaska region.

In response to requests from several State and academic organizations, NASA's Langley Research Center in Virginia fabricated several free-drifting buoys for studies of water movements near the mouth of Chesapeake Bay and along the Virginia coastline. The weight of the buoys was kept below 500 pounds to facilitate their deployment by small ships or helicopters. Techniques originally developed for the tracking of spacecraft were applied to the tracking of the buoys. The buoys are of three general types, classified in terms of the systems used to track their movements: radio buoys, radar buoys, and satellite buoys.

Radio buoys were used by the Virginia Institute of Marine Sciences (VIMS) to study the flow of nutrients through barrier island inlets, the flow of fresh water in Chesapeake Bay during the aftermath of hurricane Agnes, and the drift of shelf water. The movement of the buoys was tracked from an aircraft.

Radar buoys were used to obtain information on the circulation of water around Newport News Point for the Virginia Department of Highways for use in the planning of the second James River bridge-tunnel crossing. Radar buoys were also used by NOAA to study the influence of water movement on the formation of near-shore sand ridges. These buoys carried active radar transponders to permit tracking with a portable van-mounted radar system on shore.

Satellite buoys are being used by VIMS and the Woods Hole Oceanographic Institution to study continental shelf circulation. These buoys are equipped with transponders that work in conjunction with a platform tracking and data collection system on the French EOLE satellite which was launched by NASA. The most productive use of free drifting buoys and the EOLE satellite was made by NOAA's Atlantic Oceanographic and Meteorological Laboratories in Miami, Florida. A group of buoys placed in the Sargasso Sea operated successfully for periods of up to eight months and provided previously unavailable information on the extreme variability of surface currents in the ocean. Analysis of the results indicate that if a real coherence between current measurements at sea is expected, the measuring devices can be no farther apart than 150 km. During the sixth and seventh months of this experiment one of the buoys drifted to the Mid-Ocean Dynamics Experiment (MODE) area and provided an unexpected dividend to that project. The transponders used in all of these experiments were loaned to NASA and NOAA by the French space agency.

Technology development in spaceborne systems for position-location and data collection has advanced to the point where it will be possible to produce buoy transponder packages weighing one to two pounds with an operational lifetime of several months. Such a

package is planned for use with Nimbus-F, scheduled for launch in 1974. It will be possible, at that time, to track the movement of more than one hundred drifter buoys.

Marine Remote Sensing

Information on water color, sea surface temperature, sea surface roughness, and sea and fresh-water ice can be obtained remotely by means of sensors that respond to the visible, infrared, and microwave portions of the electromagnetic spectrum. Since no one remote-sensing technique is capable of measuring all these parameters, it is necessary to use an optimum mix of remote sensors with appropriate spectral and spatial resolution capabilities.

Considerable advances have been made in the development of multi-spectral visible remote sensors and their utilization on aircraft and satellites. Examples of such sensors are conventional cameras with different lens-filter-film combinations, television cameras with a variety of filters, and multi-spectral scanning radiometers. Data obtained with these remote sensors have been used to monitor ocean current boundary movements, delineate upwelling regions, identify regions with high bioproductivity, map contours of shallow-water bottom features, monitor the dispersal of slicks associated with oil spills and dumpings of acids and sewage sludge, and map coastal zone features.

The state of the art of infrared remote sensing has reached a stage of development where it is being used on operational NOAA satellites and NASA research and development satellites to provide thermal images depicting variations in sea surface temperatures. The newer remote sensors are providing sufficient spatial resolution to permit observations of current eddies, convergences and divergences, and water mass dynamics from satellite altitudes. Airborne infrared remote sensors are being used to monitor the heated water discharged by power plants into rivers and estuaries.

At this time the remote sensing of ocean water color can be accomplished only during daylight when the ocean surface is not obscured by haze, fog, or clouds. Depending on the choice of spectral bands, some infrared remote sensors cannot be used at night or at times of adverse weather conditions. To overcome this kind of operational constraint, NASA is now placing emphasis on the development and testing of passive and active microwave remote sensing techniques. Passive microwave remote sensors have the potential to provide information on sea surface temperature and sea roughness, and possibly information about ocean surface wind speeds and directions. Passive microwave scanning radiometers have been found to be useful in delineating the boundaries of sea ice and the distributions of new ice and multi-year ice in the Arctic region. These observations were made from aircraft altitudes.

Active microwave remote sensing techniques are under development and test to determine the feasibility of employing these techniques on aircraft and satellites for accurate measurements of the dynamic topography of the ocean surface, mean sea level, sea state and sea ice conditions, and sea surface wind speeds and directions. A vital part of these development programs is the recognition of the need for "sea-truth" data, independent observations of the sea state conditions from ships or off-shore ocean platforms required for correlation with the output signals from the remote sensor instruments.

A new sensor system is also being developed for use in the Coast Guard's program of aerial pollution surveillance for oil and hazardous substances. This program involves twice-weekly aerial flights over U.S. territorial waters and the contiguous zone, and random flights over prohibited zones as designated by the Convention on the Prevention of the Pollution of the Sea by Oil, as amended. In port areas handling over 10 million tons of petroleum per year, and in other designated areas, daily aerial flights are conducted over the harbors and at least ten miles out over the approach channels.

The Coast Guard is supporting the development of an advanced all-weather, day-night aerial oil-pollution surveillance system to be used in this program. The system will integrate infrared and ultraviolet scanning photometers with side-looking radar and dual-frequency passive microwave radiometers to detect oil slicks and map their extent and thickness. The Transportation Systems Center of the Department of Transportation is also developing an airborne laser-excitation device for the Coast Guard to permit determination of the type of spilled oil.

Aircraft Platforms

Aircraft play an important role as platforms from which experiments are carried out in the field to establish the feasibility or determine the utility of employing various types of remote sensing techniques to obtain information on marine parameters, processes, and phenomena. Over 50 aircraft remote-sensing missions were flown in 1972 by the four aircraft operated by the NASA Johnson Space Center. Thirty-five of these missions were in support of coastal zone experiments dealing with the use of remote sensing in pollution studies in bays, estuaries, and nearshore areas. Sixteen of the aircraft coastal-zone missions were in support of Earth Resources Technology Satellite (ERTS-1) investigations: six were flown over the Great Lakes area to evaluate the performance of passive microwave remote sensors as lake ice monitors, and six were flown over the North Atlantic Ocean and the Gulf of Mexico to support the acquisition of sea-state data with passive and active microwave sensors. An ocean-color mission was flown over the eastern Gulf of

Mexico in support of an ERTS-1 investigation of the Mississippi Sound.

A C-54 aircraft operated by NASA's Wallops Station was used to support several cooperative experiments with the U.S. Navy, the Army Corps of Engineers, the U.S. Coast Guard, the Environmental Protection Agency, the University of Delaware, and the Virginia Institute of Marine Sciences. These efforts were concerned with uses of passive microwave radiometers and multi-spectral band cameras to measure the amount of oil in slicks associated with oil spills. Photography delineated the boundary of the spills; the microwave radiometers provided temperature variations which could be correlated with the variations in oil thickness.

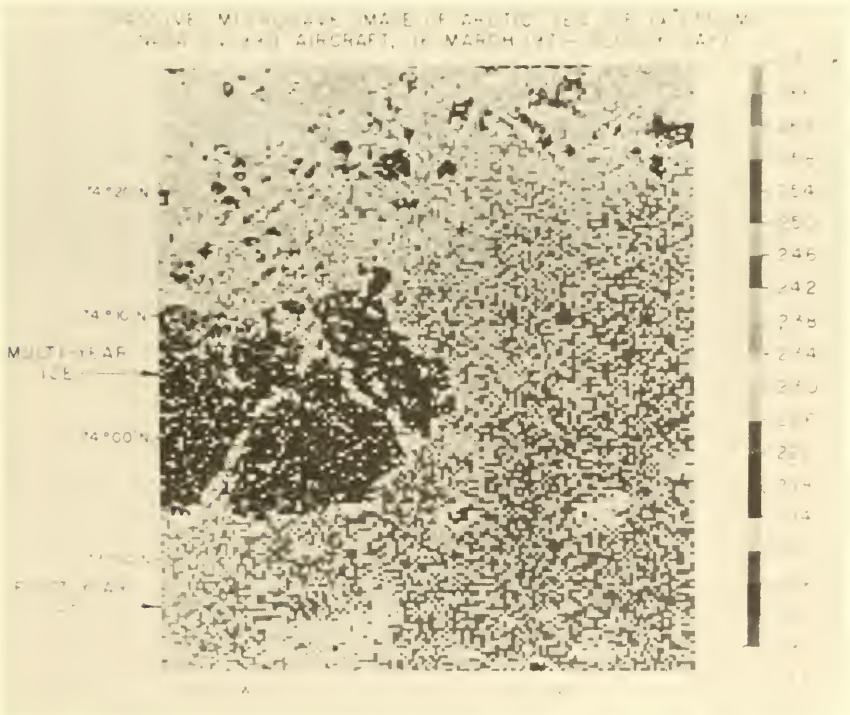
A joint experiment was carried out by NASA and Navy investigators using the Naval Research Laboratory narrow-pulse radar altimeter on the NASA Wallops aircraft to obtain sea roughness measurements. Comparison of the radar altimeter with measurements of sea-state conditions made with an accurate laser profilometer on the aircraft indicated that the use of a narrow-pulse radar system as a remote sensor for sea state measurements was feasible.

Low-altitude aircraft missions were flown over Chesapeake Bay and Lake Ontario in support of performance evaluation tests of a laser remote-sensing system designed by NASA's Wallops Station to obtain measurements of algae and phytoplankton concentrations at and near the surface of the water. The measurement technique makes use of an intense pulsed laser beam to excite fluorescence emissions and a detector to measure the strength of the emissions, which should be proportional to the concentration of the algae and phytoplankton. The data obtained were compared with surface data provided by the Environmental Protection Agency (EPA) and by NOAA.

The NASA Ames Research Center Convair 990 jet aircraft carried out flights in the Arctic region in support of experiments to assess the utility of a passive microwave scanning radiometer as a near all-weather sea-ice remote sensor. Missions were flown during March 1972 to take advantage of the presence of scientists on sea ice who were participating in the AIDJEX pilot experiment in the Beaufort Sea. Measurements were made on a day when visibility was good and on a subsequent day when the surface of the ice was obscured by clouds. The capability of employing passive microwave radiometers to obtain information on the spatial and time variations of the distributions of first-year and multi-year ice under virtual all-weather conditions was verified by comparison with information on sea-ice conditions provided by the AIDJEX scientists. A series of Convair 990 flights over the Great Lakes during early spring demonstrated the ability of the passive microwave radiometer to map the distribution of fresh-water thin ice and thick ice.

The Convair 990's high-altitude and performance capabilities were used to advantage in carrying out a number of missions during July 1972 to obtain quantitative data on the effects of atmospheric effects on remote measurements of water color. These data were obtained with a number of precision spectrometers and multispectral scanning spectrometers on the aircraft as it flew specific ground tracks at altitudes of about 45,000 feet and at 1,000 feet. Flights were coordinated with the work of scientists at sea who obtained pertinent "sea-truth" data on water color, turbidity, and chlorophyll concentrations. The data from these missions are being used in defining design and performance characteristics for ocean color remote sensors for planned satellite missions.

The NASA Convair 990 aircraft participated in a joint US/USSR experiment over the Bering Sea early in 1973. The aircraft served as a platform for visible and passive microwave radiometer remote sensors which obtained data on sea ice properties, sea state, sea



This passive microwave image of Arctic sea-ice was made from the NASA CV 990 aircraft. The dark area represents ice formed several year earlier.

surface temperature, and salinity. Data and results of experiments are to be exchanged with a view to assessing utility of employing remote sensing to investigate the Bering Sea region. (Unfortunately the aircraft and its crew were lost in a tragic accident in April 1973.)

Satellite Platforms

Requirements for the acquisition of marine environmental data on a repetitive, synoptic, and long-term basis over regions of broad extent or on a global scale can in large part be met by the use of appropriately instrumented earth-orbiting spacecraft or satellites. Such satellites can and do play three roles: platforms for marine-environment remote sensors; data-relay links for the transmission of data collected by instrumented buoys, ships, and off-shore platforms to a central data processing facility; and elements of ocean-platform position-location systems.

To date, no satellite mission has been dedicated to oceanographic data acquisition. However, satellites such as Nimbus and ITOS (for Improved TIROS Operational Satellite), and manned Gemini and Apollo earth-orbiting spacecraft, did carry sensors which obtained information on sea-ice distributions, coastal phenomena, and sea-surface temperature. In view of the progress made in high-spatial-resolution visible and infrared scanners, such sensors are being integrated into the operational NOAA series of environmental satellites. With the successful launching of the first Earth Resources Technology Satellite (ERTS-1) by NASA in July 1972, a concerted effort began to assess the feasibility and utility of employing multi-spectral images in the visible spectrum for marine environmental surveys. Such imagery has been found quite useful for investigations of marine bioproductivity, the dispersal of sewage sludge and acid waste product dumpings in offshore waters, variations in sea-ice conditions, water quality, the transport of sedimentation plumes, coastal zone processes, shallow-water bathymetry, and estuarine dynamics, and for mapping and delineating the depths of shallow-water bottom features such as shoals and bars.

The NOAA-2 Satellite, built by NASA for NOAA, and known as ITOS-D until it became operational in October 1972, is acquiring thermal data of great interest to oceanographers. This satellite carries a scanning radiometer and a very-high-resolution radiometer which have thermal channels that detect sea-surface temperature variations in cloud-free areas. Thermal imagery having a one-half nautical mile resolution is being obtained. Such data are being used by the Inter-American Tropical Tuna Commission for correlations to the tuna fisheries. The NOAA-2 thermal imagery is also providing improved sea-ice distribution data on a 24-hour basis in cloud-free areas.



Earth Resources Technology Satellite (ERTS-1) image of barrier islands separating Mississippi Sound from Gulf of Mexico. The shaded areas surrounding the islands are turbidity patterns comprised of suspended sediment.

The NASA Nimbus-5 experimental meteorological satellite launched in December 1972 carries a scanning passive microwave radiometer that is providing sea-surface temperature and sea-ice data through cloud cover. This sensor is detecting strong thermal gradient boundaries associated with major ocean currents in the Atlantic and Pacific Oceans. Until its premature malfunction, the surface-composition mapping radiometer on Nimbus-5 obtained very high quality thermal images depicting the distribution of water masses with spatial resolutions of the order of 600 feet.

Future Programs

Future programs will stress research and development of in-situ and remote sensors to achieve greater reliability of performance and more accurate measurements of marine environmental parameters, processes, and phenomena. Attention will be given to ruggedness, sensor calibration, and sensor long-term stability. Continued use will be made of buoy, aircraft, and satellite instrument platforms in testing and evaluating sensor performance. Consideration will also be given to methods and procedures for handling the processing and reduction of data collected by the instrumented platforms.

Greater emphasis will be placed on the development and testing of multifrequency passive and active microwave remote sensing techniques to take advantage of their ability to acquire data under most adverse weather conditions, both day and night. The first opportunity for such tests will be during the conduct of the manned SKYLAB mission scheduled to begin in mid-May 1973. The performance of an active microwave scatterometer and pulsed radar altimeter will be monitored and evaluated to see how well these instruments can provide data on sea state conditions and altitude measurements of ocean surface topography on a near-global basis activities. Seagoing assets consist of 38 ships, of which 17 are at the design and performance characteristics of similar types of remote sensors for use in satellite-borne demonstration experiments.

The first attempt to apply geodetic satellite technology to measurements of ocean surface topography on a near global basis will be made in the latter part of 1974 with the launching of NASA's GEOS-C satellite. This satellite will carry a pulsed radar altimeter capable of measuring the distance between the satellite and the surface of the ocean with a precision of about 50 centimeters. It is expected that relative differences in ocean surface topography of the order of one meter or larger will be detected and mapped during the one-year anticipated lifetime of the altimeter.

Initial planning is underway to take advantage of the Space Shuttle as a platform from which astronauts can assemble and place in orbit about the earth very large (100-meter diameter) antennas which are required to achieve the high spatial resolutions required of passive microwave remote sensors for monitoring coastal zone processes under day-night, near all-weather conditions. Consideration is also being given to active microwave remote sensing techniques that can provide images of waves impinging on the shores under day-night, near all-weather conditions from high altitude aircraft or satellites. The utilization of geostationary satellites as oceanographic data acquisition platforms will also be investigated.

The planning of many of the future programs will be accomplished on a cooperative basis by the agencies that are in the best position to assume responsibilities for the engineering and technological aspects of the programs and the agencies who are in the best position to judge the utility of the data products to be obtained by the advanced oceanographic data acquisition systems. It is anticipated that greater use will be made of aircraft remote sensing techniques in support of the Marine Ecosystems Analysis (MESA) program, NORPAX, and AIDJEX.

APPENDIXES

APPENDIX A—FEDERAL MARINE SCIENCE PROGRAMS, FISCAL YEARS 1972, 1973, and 1974

Budget Tables have been modified in this report to reflect changes in program emphasis which have occurred in recent years. For example, the *Endangered Species* area now identified in the budget was formerly included in the broad area of *Fisheries Resource Assessment*. Department of Defense budgets have been identified as Civil (C) for Army Corps of Engineers, and Military (M) for Navy, Defense Mapping Agency, and Advanced Research Projects Agency.

Other modifications consist of a restructuring within the major-purpose categories. In one case, two categories have been combined. Items previously included under the major-purpose categories, *Health* and *Fishery Development and Sea Food Technology*, are now listed under the new title, *Living Resources*. Several items have been transferred from one major-purpose category to another in which they more properly belong. For example, *Enforcement of Fisheries Treaties*, previously reported as an element of the *Development and Conservation of the Coastal Zone* category, has been placed in *Living Resources*. For each change between major-purpose categories in this year's budget tables, the major-purpose source from the 1972 report budget structure is identified at the end of the tables under footnote two.

APPENDIX A—FEDERAL MARINE SCIENCE PROGRAMS, FISCAL YEARS 1972, 1973, AND 1974—Continued

Appendix A-1—Federal Marine Science Program by Department and Independent Agency

[In millions of dollars]

	Estimated by Fiscal Year		
	1972	1973	1974
1. Department of Defense—Military	210.2	205.2	223.8
2. Department of Defense—Civil	30.5	33.0	31.8
3. Department of Commerce	163.8	168.0	170.9
4. National Science Foundation	65.7	57.3	61.1
5. Department of Transportation	62.8	59.1	49.6
6. Department of Interior	39.7	40.3	43.7
7. Environmental Protection Agency	21.9	24.4	24.7
8. Department of State ¹	9.5	9.8	10.3
9. Department of Health, Education, and Welfare	8.7	7.9	8.1
10. Atomic Energy Commission	6.9	7.2	7.5
11. National Aeronautics and Space Administration	4.2	7.4	7.1
12. Smithsonian Institution	2.3	2.7	3.2
Total	626.2	622.3	641.8

Appendix A-2—Federal Marine Science Program by Major Purpose—Summary

[In millions of dollars]

	Estimated by Fiscal Year		
	1972	1973	1974
1. International Cooperation and Collaboration .	9.5	10.0	10.5
2. National Security	92.1	92.9	102.4
3. Living Resources	76.4	80.5	82.1
4. Transportation	35.8	39.0	39.1
5. Development and Conservation of the Coastal Zone	94.2	91.2	88.8
6. Non-Living Resources	17.4	19.7	22.3
7. Oceanographic Research	119.4	109.9	116.1
8. Education	8.9	8.2	8.2
9. Environmental Observation and Prediction ...	34.7	31.9	37.8
10. Ocean Exploration, Mapping, Charting, and Geodesy	85.2	86.0	89.3
11. General Purpose Ocean Engineering	35.9	33.2	34.3
12. National Centers and Facilities	16.7	19.8	10.9
Total	626.2	622.3	641.8

See footnotes at the end of Appendix A—3.

APPENDIX A—FEDERAL MARINE SCIENCE PROGRAMS, FISCAL YEARS 1972, 1973, AND 1974—Continued

Appendix A-3—Federal Marine Science Program by Major Purpose—Detail by Subpurpose and Agency

[In millions of dollars]

	Estimated by Fiscal Year		
	1972	1973	1974
1. International Cooperation and Collaboration	9.5	10.0	10.5
(a) Marine science activities of			
International organizations	6.3	6.5	6.6
Department of State	(6.3)	(6.4)	(6.5)
National Science Foundation	(0.0)	(0.1)	(0.1)
(b) International fisheries commissions	3.1	3.3	3.8
Department of State			
(c) Assistance to developing			
nations	0.1	0.2	0.1
Agency for International			
Development	(0.1)	(0.1)	(0.0)
National Science Foundation	(0.0)	(0.1)	(0.1)
2. National Security	92.1	92.9	102.4
(a) Defense oriented surveys and			
services	19.8	21.3	21.5
Department of Defense—Military			
(b) Marine science support for			
defense systems	42.0	41.4	46.6
Department of Defense—Military			
(c) Ocean Engineering for Defense			
purposes	30.3	30.2	34.3
Department of Defense—Military			
3. Living Resources ²	76.4	80.5	82.1
(a) Fishery resource assessment, develop-			
ment and management	39.7	39.8	39.7
Department of Commerce			
(b) Technical and economic			
assistance to the commercial			
fishing industry	8.0	7.7	8.2
Department of Commerce			
(c) Protection of endangered species,			
marine mammals research4	1.2	2.1
Department of Commerce			
(d) Health, sanitation, contaminants,			
and inspection	5.5	5.1	5.7
Department of Commerce	(1.0)	(1.0)	(1.0)
Department of Health, Education,			
and Welfare	(4.5)	(4.1)	(4.7)
(e) Fish protein concentrate	1.6	0.2	0.0
Department of Commerce			
(f) Enforcement of fisheries treaties	17.1	22.8	23.1
Department of Commerce	(1.2)	(1.2)	(1.2)
Department of Transportation	(15.9)	(21.6)	(21.9)
(g) Use of marine life in			
biomedical research	4.1	3.7	3.3
Department of Health, Education,			
and Welfare			

See footnotes at the end of Appendix A—3.

APPENDIX A—FEDERAL MARINE SCIENCE PROGRAMS, FISCAL YEARS 1972, 1973, AND 1974—Continued

Appendix A-3—Federal Marine Science Program by Major Purpose—Detail by Subpurpose and Agency—Continued

[In millions of dollars]

	Estimated by Fiscal Year		
	1972	1973	1974
4. Transportation ²	35.8	39.0	39.1
(a) Maritime science and technology; advanced ship engineering develop- ment	12.8	15.4	15.5
Department of Commerce			
(b) Shipping economics and requirements; improvement in ship operations and shipping systems	7.8	7.9	7.6
Department of Commerce			
(c) Deep water ports/offshore terminal development	1.3	2.6	0.3
Department of Defense—Civil	(1.0)	(2.0)	(0.0)
Department of Commerce	(0.3)	(0.6)	(0.3)
(d) Channel and harbor improvement	5.0	6.0	6.0
Department of Defense—Civil			
(e) Aids to navigation	5.1	4.3	4.8
Department of Commerce	(2.0)	(1.0)	(1.5)
Department of Transportation	(3.1)	(3.3)	(3.3)
(f) Merchant Marine safety; search and rescue	3.8	2.8	4.9
Department of Transportation			
5. Development and Conservation of the Coastal Zone ²	94.2	91.2	88.8
(a) Marine pollution abatement and control	51.5	44.2	39.4
(1) Water quality enhancement; environmental studies, standards, and criteria			
Environmental Protection Agency .	(10.3)	(9.1)	(9.3)
Department of Defense—Civil	(0.5)	(0.5)	(0.5)
Department of Commerce	(0.3)	(0.3)	(0.5)
Department of the Interior	(0.8)	(0.8)	(0.2)
(2) Control and removal of pollutants			
Department of Transportation ³	(17.8)	(11.0)	(6.0)
Environmental Protection Agency .	(4.2)	(3.7)	(3.6)
Department of Defense—Civil	(3.2)	(2.5)	(3.0)
(3) Surveillance and regulatory activities			
Environmental Protection Agency .	(7.4)	(11.6)	(11.8)
Department of Defense—Civil	(4.5)	(4.0)	(2.5)
Department of Transportation ³	(2.5)	(0.7)	(2.0)
(b) Conservation and recreation	30.0	30.3	32.4
(1) Conservation of marine locales, gamefish, and wildlife			
Department of the Interior	(13.0)	(13.7)	(12.9)

See footnotes at the end of Appendix A-3.

**APPENDIX A—FEDERAL MARINE SCIENCE PROGRAMS,
FISCAL YEARS 1972, 1973, AND 1974—Continued**

**Appendix A-3—Federal Marine Science Program by Major
Purpose—Detail by Subpurpose and Agency—Continued**

[In millions of dollars]

	Estimated by Fiscal Year		
	1972	1973	1974
(2) Planning and development of marine areas for recreation			
Department of the Interior	(5.6)	(7.4)	(8.9)
(3) Boating safety			
Department of Transportation	(0.6)	(0.6)	(1.1)
(4) Small craft harbor development			
Department of Defense—Civil	(3.0)	(3.6)	(4.5)
(5) Beach and shore stabilization; hurricane storm surge protection			
Department of Defense—Civil	(3.5)	(5.0)	(5.0)
Department of Interior ¹	(4.3)	(0.0)	(0.0)
(c) Regional environmental systems research (Chesapeake and San Francisco Bays, N.Y. Bight, Great Lakes, etc.)	12.7	16.7	17.0
Department of Defense—Civil	(7.2)	(8.0)	(9.0)
Department of Commerce	(2.4)	(5.5)	(4.7)
National Science Foundation	(2.6)	(2.5)	(2.5)
Smithsonian Institution	(0.5)	(0.7)	(0.8)
6. Non-living Resources	17.4	19.7	22.3
(a) Assessment, investigation, and appraisal of minerals, fossil fuels, sand, and gravel	2.6	4.5	5.3
Department of Defense—Civil	(0.2)	(0.1)	(0.1)
Department of the Interior	(2.4)	(4.4)	(5.2)
(b) Leasing and management	8.6	9.6	13.2
Department of the Interior			
(c) Environmental impact of mining	1.2	1.2	0.5
Department of Commerce			
(d) Development and protection of fresh water supplies	5.0	4.4	3.3
Department of the Interior			
7. Oceanographic Research ²	119.4	109.9	116.1
(a) Atomic Energy Commission	5.4	6.3	6.6
(b) Department of Defense—Military	30.0	27.3	28.4
(c) Department of Commerce	19.7	20.5	21.7
(d) Department of Transportation	1.2	0.4	0.2
(e) National Science Foundation	61.8	53.9	57.6
(f) Smithsonian Institution	1.3	1.5	1.6
8. Education	8.9	8.2	8.2
(a) Department of Commerce	4.4	4.9	4.9
(b) Department of Defense—Military	2.8	2.2	2.1
(c) Department of Transportation	0.3	0.3	0.3
(d) National Science Foundation	1.3	0.7	0.8
(e) Department of Health, Education, and Welfare	0.1	0.1	0.1

See footnotes at the end of Appendix A-3.

**APPENDIX A—FEDERAL MARINE SCIENCE PROGRAMS,
FISCAL YEARS 1972, 1973, AND 1974—Continued**

**Appendix A-3—Federal Marine Science Program by Major
Purpose—Detail by Subpurpose and Agency—Continued**

[In millions of dollars]

	Estimated by Fiscal Year		
	1972	1973	1974
9. Environmental Observation and Prediction ² ..	34.7	31.9	37.8
(a) Data acquisition, processing and dissemination	32.5	29.6	35.1
Department of Defense—Military	(13.4)	(12.9)	(14.0)
Department of Defense—Civil	(2.4)	(1.3)	(1.2)
Department of Commerce	(10.3)	(11.2)	(15.2)
Department of Transportation	(6.4)	(4.2)	(4.7)
(b) Model studies and development	2.2	2.3	2.7
Atomic Energy Commission	(0.6)	(0.3)	(0.2)
Department of Commerce	(1.6)	(2.0)	(2.5)
10. Ocean Exploration, Mapping, Charting, and Geodesy ²	85.2	86.0	89.3
(a) Nautical charts	38.8	39.7	42.5
Department of Defense—Military	(21.2)	(21.4)	(23.5)
Department of Commerce	(17.6)	(18.3)	(19.0)
(b) Coastal mapping	19.8	19.9	22.2
Department of Defense—Military	(14.8)	(14.9)	(17.0)
Department of Commerce	(5.0)	(5.0)	(5.2)
(c) Geophysical mapping	26.6	26.4	24.6
Department of Defense—Military	(22.4)	(22.6)	(24.6)
Department of Commerce	(4.2)	(3.8)	(0.0)
11. General Purpose Ocean Engineering ²	35.9	33.2	34.3
(a) Systems development (satellite, aircraft, and other sensor and instrument development)	7.3	11.1	12.1
National Aeronautics and Space Administration	(4.2)	(7.4)	(7.1)
Department of Commerce	(3.1)	(3.7)	(5.0)
(b) Data buoy systems	12.7	9.5	8.5
Department of Commerce			
(c) Deep ocean technology	13.5	11.0	11.8
Department of Defense—Military			
(d) Manned undersea technology	1.5	1.0	1.2
Department of Commerce	(1.5)	(1.0)	(1.0)
Smithsonian Institution	(0.0)	(0.0)	(0.2)
(e) Power plant sitings; nuclear power sources	0.9	0.6	0.7
Atomic Energy Commission			

See footnotes at the end of Appendix A-3.

APPENDIX A—FEDERAL MARINE SCIENCE PROGRAMS, FISCAL YEARS 1972, 1973 AND 1974—Continued

Appendix A-3—Federal Marine Science Program by Major Purpose—Detail by Subpurpose and Agency—Continued

[In millions of dollars]

	Estimated by Fiscal Year		
	1972	1973	1974
12. National Centers and Facilities ²	16.7	19.8	10.9
(a) National Oceanographic Data Center ³ ..	3.0	3.1	3.1
Department of Commerce			
(b) National Climatic Center	0.1	0.1	0.1
Department of Commerce			
(c) Smithsonian Oceanographic Sorting			
Center	0.3	0.3	0.3
Smithsonian Institution			
(d) Mediterranean Marine Sorting			
Center	0.2	0.2	0.3
Smithsonian Institution			
(e) National Oceanographic Instrumentation			
Center	1.9	1.9	1.9
Department of Commerce			
(f) Polar Icebreakers	11.2	14.2	5.2
Department of Transportation ³			

¹ Includes Agency for International Development budgets.

² Living Resources includes funds listed in the 1972 report under Fishery Development and Seafood Technology and under Health; Department of Transportation funds for Enforcement of Fisheries Treaties, previously listed under Development and Conservation of the Coastal Zone, are transferred to Living Resources.

Transportation includes Department of Transportation funds for Search and Rescue listed in the 1972 report under Development and Conservation of the Coastal Zone.

Development and Conservation of the Coastal Zone includes Department of Transportation funds for Marine Law Enforcement and Boating Safety listed in the 1972 report under Transportation; some of the Department of Defense funds for Pollution Abatement and Control previously under Transportation; some of the Department of Commerce and Smithsonian Institution regional projects previously under Oceanographic Research.

General Purpose Ocean Engineering includes Manned Undersea Activities of the Department of Commerce previously listed under Ocean Exploration, Mapping, Charting, and Geodesy and all of the NASA Satellite Sensor Development funds previously listed under Environmental Observation and Prediction.

National Centers and Facilities includes the funds listed in the 1972 report under National Data Centers; Department of Transportation funds from Oceanographic Research and Environmental Observation and Prediction; and Department of Commerce's National Oceanographic Instrumentation Center previously listed under General Purpose Ocean Engineering.

³ Fluctuations in Department of Transportation programs result from nonrecurring expenditures for capital equipment.

⁴ FY 1972 non-recurring National Park Service appropriation to stabilize storm-damaged beaches.

⁵ The Great Lakes Center, separately identified in the 1972 report, has been included as part of the National Oceanographic Data Center budget.

APPENDIX B—FEDERAL MARINE SCIENCE ACTIVITIES BY AGENCY

Department of Defense

Department of Defense ocean programs support both military and civil purposes. The programs of the Navy, the Defense Mapping Agency, and the Advanced Research Projects Agency are directed to meeting military requirements. The marine programs of the Army Corps of Engineers fall in the civil-works category.

Navy ocean science, engineering, and operational programs are conducted at 50 academic institutions, 20 research laboratories, and 55 industrial activities, as well as many of the Navy's 41 R&D field activities. Seagoing assets consist of 38 ships, of which 17 are at universities, 4 are at Navy laboratories, 12 are at the Naval Oceanographic Office, 1 is on loan to the National Science Foundation, and 4 are on loan to foreign governments. Also there are 4 aircraft which are primarily used for ocean work. The Navy's family of 10 deep submersible vehicles (DSV) provides a set of *in situ* platforms for manned observations into the sea at depths up to 20,000 feet; 98 percent of the ocean floor is within this depth range.

Since the conduct of oceanography is "big science", involving major commitment of high-cost assets, the Navy attempts to participate in cooperative programs wherever possible and beneficial to Navy needs. This includes both domestic and foreign oceanographic programs where pooling of resources can provide results normally not available to a single agency.

Last year the Defense Mapping Agency (DMA) was created to put all DOD mapping, charting, and geodesy under one central agency. The Naval Oceanographic Office (NAVOCEANO) transferred its chart production and distribution capability to DMA, but the Navy still has the responsibility for the acquisition of the survey data and the development of related technology for the DMA. In addition, the remaining portion of NAVOCEANO continues to conduct its applied military oceanography work in providing the Fleet with operational environmental data.

As the capability of surveillance and detection systems increases in both range and sensitivity, it is imperative that environmental information for the Fleet be of equivalent quality to permit full use of sensor capability. Consequently, the scale of Navy oceanographic work has increased dramatically. This increase in scale and better product distribution have been two of the most important challenges for the Navy's ocean program.

In ocean engineering the Navy is devoting much of its effort to the development of technology and work systems for search, location, classification, and recovery at great depths. The recently tested

Large Object Salvage System (LOSS) salvage pontoon will permit the recovery of objects weighing up to 100 tons from water depths of 850 feet when development is complete. Through the use of hydrazine gas generators, it is hoped to extend LOSS capabilities to 20,000 feet, though lift capacity will be reduced to perhaps 10 tons at this greater depth. Currently there is under development an unmanned, cable-controlled device called the Remote Underwater Work System (RUWS), which will provide a 20,000 foot capability for search, location, classification, and limited recovery. This system will complement the manned, 20,000-foot-capable Bathyscaph Trieste II. Also there are operational recovery systems in the CURV family (Cable-controlled Underwater Recovery Vehicle) which are capable to 7,000 feet. This year one CURV is being converted to a 10,000 foot working depth.

The deep submersible *Alvin*, which is operated for the Navy by Woods Hole Oceanographic Institution, will have its working depth upgraded from 6,000 feet to 12,000 feet this year through the installation of a new titanium pressure hull, new electronics, high-pressure ballast pumps, and other new equipment.

The Navy's two Deep Submergence Rescue Vehicles (DSRV) are undergoing their test and evaluation at San Diego. Last year actual underway hookups were made between DSRV-1 and a mother submarine while submerged, and people were transferred during the operations.

Navy's extensive past efforts in development of diving equipment and techniques provided the capability and technology which permitted the completion of a working dive at sea to a depth of 1010 feet. This Navy dive was a world's record for an open-ocean dive. Developments in heating, physiological monitoring, communications, gas mixing, masks, and tools are continuing.

The major medical program established in 1968 to provide for health maintenance of swimmers and divers has determined thermal requirements for divers, completed a sample X-ray survey of U.S. Navy divers for incidence of aseptic bone necrosis, and developed an improved transcutaneous bubble-detection device which is under field evaluation. Studies have also been initiated with animals to test drugs protective against decompression sickness and oxygen toxicity.

Although the Navy is both producer and consumer of its own efforts in oceanography, it provides much of the data and technology used by the civil sector. Conservatively, about 90 percent of the Navy ocean program is unclassified and can therefore be made available immediately to meet civil requirements.

The Advanced Research Project Agency (ARPA) is continuing its support of research and development to improve work systems for deep-submergence vehicles and to provide more precise navigation for undersea operations.

The marine science programs of the Corps of Engineers support

coastal and Great Lakes investigations of water and related land resources. The broad spectrum of Corps Civil Works responsibilities in these areas includes comprehensive long-range planning, preauthorization project development, design, construction, operation and maintenance of projects, and regulatory activities. Project purposes include navigation, beach and shore erosion protection, coastal flood control, water quality improvement and flow control, water-based recreation, fish and wildlife conservation and enhancement, floodplain management services, and other purposes authorized by law. The problems of developing and using natural resources to meet the needs of people and industry are balanced with the need to protect and enhance environmental values for present and future generations.

The Civil Works Directorate, Office of the Chief of Engineers, is responsible for the overall management of the marine science activities under the Corps Civil Works programs. These are accomplished through 9 coastal and Great Lakes division offices, 20 operating offices, and 5 major research centers. U.S. Army Engineer laboratories and special installations with Civil Works programs in marine science include: the Coastal Engineering Research Center, Fort Belvoir, Virginia; the Waterways Experiment Station, Vicksburg, Mississippi; the Institute for Water Resources, Ft. Belvoir, Virginia; the Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire; and the Waterborne Commerce Statistics Center, New Orleans, Louisiana. Marine science activities are accomplished inhouse, by other public agencies, and by academic, non-profit, and industrial institutions. A wide range of disciplines is involved, including engineering and physical sciences, economics and other social sciences, and environmental and ecological sciences, which all interface with the marine sciences.

The purpose of Corps navigation studies and programs is improvement of coastal and Great Lakes waterways and harbors to provide safe and economical waterborne movement of commodities, commercial fishing, and recreational boating. In conjunction with rail and truck transportation, the inland waterways are planned to meet ever-growing needs of commerce and industry. Individual studies and detailed planning of construction projects are specifically authorized by Congress to deepen, widen, and maintain harbors and waterways, and to provide safe entrance channels and major access channels. Provision of public landings, wharves, berth areas, terminals, marinas, and other shore facilities are the responsibility of non-Federal interests; they frequently involve large investments.

The shore protection studies of the Corps, in cooperation with State and local interests, develop programs to halt erosion, restore or enhance shores for public recreation, park, and wildlife refuge uses; and to protect against tidal and hurricane flooding. Federal

participation in beach and shore stabilization projects is justified mainly by public recreational use. Coastal storm flood protection is usually justified economically by prevention of damage, generally for concentrated developments in exposed locations. A major national assessment of shore erosion was completed in 1972.

The marine pollution abatement and control mission of the Department of Army originally stemmed from laws that were concerned primarily with protection of the navigable waterways of the United States. This mission has been modified somewhat by recent legislation. Corps permits are required for dredging, filling, and construction on navigable waters, with full consideration of impacts on all factors of the public interest, including environmental values. The Corps reviews all permit applications submitted to EPA for discharges into navigable waters to determine the impact on navigation.

The estuarine studies of the Corps have a broad spectrum of planning purposes, including navigation, sedimentation, water quality and utilization, recreation, flood plain and wetlands management, fish and wildlife protection, and preservation and enhancement of natural values and environmental quality. Estuarine studies of several major estuaries have included Chesapeake Bay, San Francisco Bay, Delaware Bay, Mobile Bay, and Galveston Bay, and utilized team efforts with States and other Federal agencies to gain better understanding of physical and biological processes. Supported by hydraulic (physical) and mathematical models, the interdisciplinary studies and research efforts are directed to the solution of water resources problems and analysis of alternative management plans.

Department of Commerce

Two agencies of the Department of Commerce, the National Oceanic and Atmospheric Administration (NOAA) and the Maritime Administration (MARAD), contribute to the Federal Ocean Program.

The basic missions of NOAA are the development, operation, and maintenance of a national system for observing and predicting the state of the atmosphere, the rivers, and the oceans, and the conduct of research and development that contributes to the exploration, conservation, and development of marine resources. Additionally, an essential part of the NOAA program is the development of the necessary scientific understanding, technological capabilities, and support services required to carry out the foregoing missions.

NOAA's major activities are the following:

MAPPING, CHARTING, AND SURVEYING SERVICES

The National Ocean survey (NOS) provides nautical charts which are basic tools required for waterborne commerce, expanding marine

industries, and recreational boating. Program activities include hydrographic surveying, and the compilation, reproduction, and distribution of nautical charts, coast pilots, Great Lakes Pilot, and other publications.

Coastal mapping and services provide graphic and descriptive coastal delineation, tidal data, and prediction services for our coastal areas (including the Great Lakes). Some of the principal products are hydrographic control data and coastal zone information, special base-line boundary maps, coastal evacuation routes, and tide tables.

Ocean mapping, investigation, and services consist of the acquisition and dissemination in suitable form of scientific data necessary to the support of many types of marine activities. The products include charts depicting bottom topography, ocean currents, and other physical variables of importance to resource conservation and development and to pollution control programs.

OCEAN FISHERIES AND LIVING MARINE RESOURCES

The National Marine Fisheries Service (NMFS) seeks to develop means to assess, protect, and allocate living marine resources for their wise use and maximum benefit to man. The Service conducts biological research on fish and shellfish to serve as the basis for promoting the conservation and management of fishery resources. Product quality research is conducted to improve and develop methods for handling, processing, transporting, and preparing fishery products. Economic research is conducted on investments in U.S. fisheries, product demand, foreign fishery trade, and institutional barriers to the fishing industry. Marketing research encourages the flow of domestic fishery products in commerce. Services to the fishing industry include collection and dissemination of statistics and market information. Federal assistance programs provide funds to the States to study, develop, and manage fishery resources. Disaster aid is provided to States suffering from commercial fishery failures due to natural disasters. NMFS administers a fishery loan fund for vessels and gear, a vessel mortgage insurance program, and a program for reimbursement of costs associated with foreign seizures of U.S. fishing vessels. NMFS has the responsibility for managing the Pribilof Islands fur seal herds, as well as administration of the Islands. Under the Marine Mammal Protection Act of 1972, a research and management program is being conducted to provide for protection of marine mammals. The research effort also provides basic information for negotiation of international agreements as may be required. Enforcement and surveillance programs assure compliance with international fishery agreements and treaties and protection of fishery stocks under U.S. jurisdiction from foreign fishing activity.

ENVIRONMENTAL SATELLITE SERVICES

The National Environmental Satellite Service (NESS) manages and operates the national operational environmental satellite system, composed of earth-orbiting spacecraft equipped to observe and collect environmental data on a global basis. Images of the earth and clouds and measurements of radiation from the atmosphere and ocean surface are acquired and processed at the World Meteorological Center in Washington for application to weather, marine, hydrologic, and resource survey services. Regular products include charts of sea surface temperature, sea ice, and snow cover for the Northern and Southern Hemispheres, and cloud cover and other meteorological data. Future products will include surface current patterns, sea state, pollutant plume delineation, shoreline changes due to storm action, and marine biological processes significant for fisheries resource studies.

THE NATIONAL SEA GRANT PROGRAM

The Sea Grant Program is the principal national instrument for carrying out cooperative programs in the coastal zone with state and local governments, academic institutions, and industry for the purpose of fostering marine resource development, technology, environmental research, education and training, and advisory services. Its major activities include assisting coastal states to improve their abilities to manage their coastal zones through research, education, and advisory services; facilitating the ability of private enterprise to explore for and utilize marine resources and engage in marine commerce and commercial recreational activities through technology development, identification of new or unutilized marine resources, and providing the information required for the solutions to socio-economic and legal problems; operating and managing a National Marine Advisory Program to facilitate the transfer of information between researchers and users; and helping provide the skilled manpower required to meet national needs in marine activities. More detailed information is reported in Appendix C.

ACTIVITIES IN THE COASTAL ZONE

The principal areas of activity in the coastal zone are as follows:

Marine Ecosystems Analysis

Marine ecosystems investigations in selected areas consist of studies of the ecology of the marine environment, changes in that ecology which result from human activity, impacts of those changes, and the development of ecological descriptions to provide a reference base for planning and managing future uses of marine resources in such a way as to have minimum adverse impact on the environment.

Manned Underwater Activities

This program provides manned underwater support to investigations of marine environmental problems. Undersea platforms are used to support resource development and research projects of NOAA, universities, and other non-Federal organizations. Examples of supported projects are: the determination of sedimentary processes leading to the formation of petroleum resources, ecological and environmental surveys in regions where shellfish and other food stocks have been depleted, and investigations of the movement of sediment, pollutants, and the structure of submarine canyons on the continental shelves. NOAA is working closely with the Navy in submersible and life-support technology programs.

Coastal Zone Management

Under the Coastal Zone Management Act of 1972, NOAA is authorized to encourage and assist Federal, State, and local governments and regional agencies in the development and operation of coastal zone management programs. It is to serve as a focal point for coordination with and assistance to governmental, public, industrial, academic, and other institutions concerned with coastal zone management.

OCEANOGRAPHIC RESEARCH

NOAA's oceanographic research program is conducted primarily by the Atlantic Oceanographic and Meteorological Laboratories (AOML). Included are studies of the dynamics of the upper oceanic boundary layer, the role of internal waves in the over-all dynamics of the water column, investigations of the open ocean and continental shelf characteristics of the tide wave, and investigations of the current patterns in the Caribbean Sea, the Gulf of Mexico, and the Gulf Stream. The Trans-Atlantic Geotraverse (TAG) is aimed at providing complete knowledge of the geology and geophysical characteristics of a three-degree strip between Cape Hatteras and Cape Blanc, Mauritania. These projects provide the basic deep-sea geophysical knowledge from which understanding of basic geological processes is formed. AOML is also conducting work directed toward understanding the role of submarine canyons as possible conduits for transporting seafloor material, including dumped wastes, out into the deep sea. A small group of physicists and oceanographers at AOML is working closely with other components of NOAA and NASA in the utilization of satellites for oceanographic research.

ENVIRONMENTAL DATA AND INFORMATION SERVICES

These services include environmental data indexing, archiving, retrieval, selected summaries and analyses, and dissemination and

environmental information services supporting government, public, academic, and industrial users. NOAA's Environmental Data Service, as a true family of data and information centers, is making considerable progress towards its interdisciplinary goal of "one-stop service" to its user communities. EDS is comprised of the National Oceanographic Data Center, the National Climatic Center (marine climatology), the National Geophysical and Solar-Terrestrial Data Center (marine geology and geophysics, including seismology, gravimetry, and geomagnetism), the Environmental Science Information Center, and the Center for Experiment Design and Data Analysis. Six discipline-oriented World Data Centers (dating from IGY) are collocated with EDS data centers.

OCEANOGRAPHIC INSTRUMENTATION

The National Oceanographic Instrumentation Center (NOIC) provides a federal service for calibrating and testing oceanographic instrumentation for government, academic, and industrial interests. NOIC maintains technical capability and facilities to simulate ocean environmental conditions. It establishes reference standards, develops calibration methodology, and tests and evaluates instrumentation for accuracy and reliability.

The National Ocean Survey has the responsibility for developing and demonstrating the capability to deploy data buoy systems for oceanographic and atmospheric observations in order to support marine industrial development, commerce, and recreation.

MARAD's research and development program is divided into three broad areas:

ADVANCED SHIP DEVELOPMENT

The principal objectives of the advanced ship development program are: first, to reduce cost and increase productivity of building and operating U.S. flag ships, through improved ship designs, shipbuilding regulations, and new shipbuilding techniques, including automation of design, of construction, and of management and control of production; and second, to improve shipping systems to be built or converted in the next two decades. The program includes for example, development of first-generation Liquefied Natural Gas (LNG) ships and modernization of first-generation container ships in the '70's and of new shipping systems for the 80's, such as advanced LNG ships or a new class of vessels intermediate between bulk and container ships. These would carry cargoes of a semi-manufactured nature such as finished steel or newsprint, not suitable for either container ships or bulk carriers.

ADVANCED SHIP AND PORT OPERATIONS

The objectives of this effort, which includes deepwater terminal systems, are to maximize cargo throughput at least economic cost

and to improve operational safety. The safety aspect is directed especially at eliminating collisions and stranding, which cause enormous losses to the shipping industry each year and contribute to high operating costs. These programs deal with automated ships, advanced navigation/communication systems, computer-aided cargo operations and management, advanced ports, terminals, and intermodal systems, and ice-transiting systems.

MARITIME TECHNOLOGY

The objectives here are to provide technical support to ongoing programs in advanced ship development operations. These include projects in hydrodynamics and ship structural research, propulsors, and maintenance and repair; to develop technical innovations through marine science and ship component development, e.g., new propulsion and transmission systems, marine nuclear power plants and other components; and to develop systems which will reduce and control ship-generated pollution.

National Science Foundation

The National Science Foundation supports basic and applied oceanographic research at academic, non-profit, and industrial institutions, as well as in Federal agency laboratories. Seven offices within the Foundation fund research programs as well as provide support for the ships and equipment necessary to carry them out.

The International Decade of Ocean Exploration (IDOE) is the Foundation's major directed marine research effort. Its basic objective is to accelerate understanding and prediction of the oceans and their resources through support of large-scale, multi-institutional, international projects. Programs are in four areas: Environmental Quality, Seabed Assessment, Environmental Forecasting, and Living Resources.

The Oceanography Section of the Division of Environmental Systems supports individual investigators in physical, chemical, and biological oceanography, submarine geology and geophysics, and physical limnology. Fundamental knowledge of marine problems and processes stems from these diverse research projects. The Atmospheric Section supports programs in air-sea interactions with primary emphasis on projects with meteorological significance. Marine population and ecological studies are emphasized in Biological Oceanography, while support from the Division of Biological and Medical Sciences is directed toward experimental studies of individual marine organisms.

Research in coastal zone regions is the marine science emphasis within the Foundation's Research Applications Directorate (RANN). The emphasis of the coastal zone program is to provide an integrated research effort into four broad areas: (1) estuarine effects of waste discharge and dumping, (2) effects of engineering construction

activities, (3) management strategies for ecologically important areas like marshlands, and (4) methods for restoring damaged areas. The goal is to define workable strategies for resolving conflicts between regional growth and development and environmental quality.

Knowledge about the origin and history of the oceanic basins and the continents is the objective of the Ocean Sediment Coring Program (OSCP). The major activity of the OSCP is the Deep Sea Drilling Project (DSDP), which uses the scientific drilling ship, *Glomar Challenger*, to obtain samples by drilling and coring the sedimentary layers of the seabed.

Lead responsibility for polar research rests with the Office of Polar Programs (OPP), which coordinates and supports research in the Arctic and Antarctic. Fundamental objectives are: the determination and prediction of the role played by sea-ice in influencing oceanic and atmospheric circulation patterns (hence on the world climate), marine ecosystem studies, population dynamics of marine mammals, and low-temperature research on marine organisms in Antarctic waters.

Support for the equipment and ships necessary to conduct these programs is provided by the Office of Oceanographic Facilities and Support (OFS). With the exception of ship support provided by the Offices of Polar Programs and the Ocean Sediment Coring Program, all Foundation funds for ship support are programmed through the OFS. Support is also provided for the operation of facilities other than ships, and for the acquisition of capital equipment and improvement of shore facilities. The objectives are to maintain and improve a cooperative system of academic facilities with operational capability at key locations and to promote the shared use of such facilities through the University National Oceanographic Laboratory System (UNOLS).

In addition, the Foundation, through the Educational Directorate, provides support for developing instructional programs and training students and teachers in the marine sciences.

Department of Transportation

The U.S. Coast Guard, maritime arm of the Department of Transportation, has as its main mission safety of life and property at sea, and the enforcement of maritime laws and treaties, particularly as they relate to pollution prevention and fisheries conservation.

The former mission includes search and rescue, aids to navigation, merchant marine safety, and recreational boating safety. Ancillary to and in support of both of the main missions are the collection of oceanographic data by ocean station vessels, oceanographic vessels, and polar icebreakers, the processing of such data, and the entire Coast Guard Research and Development program.

The R and D program goals are to apply the benefits of science and technology to Coast Guard missions and responsibilities, to improve service to the public, and to reduce costs. To achieve these goals, three major objectives have been identified. These are (1) to increase the capacity of the national marine transportation system, (2) to protect and enhance the marine environment, and (3) to protect public safety at sea.

Projects fall into two general classes. One class involves actual hardware development for use by the Coast Guard. These are generally more costly programs. The second class are those projects designed to provide technical knowledge to support commercial vessel and boating safety technical regulations. In selection of the projects, the following factors are evaluated: (1) requirements resulting from new legislation, (2) marine casualty reports and trends, (3) potential for cost savings, and (4) assessment of technical risks involved.

The enactment of recent legislation such as the Water Quality Improvements Act of 1970, the Boat Safety Act of 1971, and the Port and Waterways Safety Act of 1972 have substantially increased the CG's safety and environmental duties and responsibilities. For example, under Title II of the Port and Waterways Safety Act, major emphasis will be directed towards the development of technical knowledge to implement new or revised standards for design, construction, alteration, and repair of vessels and their equipment, as well as new standards affecting vessel maneuvering and stopping ability. Also, in response to Title II, continued development of Vessel Traffic Systems, including the buoy subsystem and a precision navigation system (River and Harbor Aids to Navigation System called RIHANS) will be emphasized.

The Boat Safety Act of 1971 is intended to enhance the safety of the operation of the 8,000,000 recreational boats in the U.S. as well as provide consumer protection for their owners. Major emphasis is planned and necessary in this program area to provide the timely support needed to develop and verify minimum safety standards for these boats and their equipment.

In response to the Water Quality Improvement Act of 1970, the development of the high-sea oil control and clean-up system and Arctic and fast-current clean-up systems will be continued. Major emphasis is being directed towards the continued development of airborne and "in situ" oil surveillance systems.

Finally, in the area of search and rescue, major emphasis is focused on the testing, modification, and integration of existing sensors to develop an effective airborne detection system, as well as continued work on the development of the distress alerting and detection system for search and rescue and other applications such as vessel traffic systems and buoy position monitoring.

Department of the Interior

The Department of the Interior contributes to the Federal Ocean Program through activities that relate to determination and development of the Nation's non-living and recreational resources. In response to the challenge outlined by the President in his April 18, 1973 Energy Message to the Congress, emphasis is being placed on those activities that will accelerate production of petroleum from beneath the Federal Lands of the Outer Continental Shelf (OCS) and expedite delivery of foreign oil and gas to U.S. markets. The Department continues to place high priorities on activities that will assure adequate supplies of fresh water within the coastal zone, protect gamefish and wildlife, and develop the esthetic and recreation values of our natural environment in order that they may be appreciated and enjoyed by both present and future generations. Increasing attention is being devoted to interrelationships between land and offshore development, to possible future recovery of sand and gravel from the continental shelves to meet needs of heavily populated areas, and to factors involved in mining manganese nodules and other minerals from the seabed of the deep oceans.

The Department's U.S. Geological Survey and Bureau of Land Management have evaluation, regulatory, and advisory functions that are fundamental to the success of Government efforts to meet those aspects of the President's energy challenge that involve offshore areas. These functions, and activities being undertaken to fulfill them, are described in Chapter III of this report.

In addition to its important role in the energy challenge, the U.S. Geological Survey continues a wide variety of general-and special-purpose investigations of geologic and hydrologic conditions, resources, and hazards to obtain information that is needed for planning and development in coastal and offshore areas. Many of these investigations are undertaken in cooperation with other Federal agencies, the States, various municipalities, and, in a few cases, foreign governments. They include maintenance of a stream gauge network that now provides an inventory of nearly all surface-water runoff from land to the Nation's coastal waters. The Survey has regulatory responsibility for technical supervision of mineral as well as oil and gas development and extraction on the OCS to ensure that mineral resources of government-owned lands will be developed in an orderly and safe manner, that maximum recovery will be achieved, and that the government will be fully compensated for resources removed from on or beneath its offshore lands.

Although most effort is now being devoted to Outer Continental Shelf leasing and associated functions, the Bureau of Land Management remains a focal point for development of Departmental and Federal policies that may be applied to future development of mineral resources on the outer shelves.

The Office of Water Resources Research currently supports

research, mostly in academic institutions, that is designed to aid in the protection and rehabilitation of estuarine resources and to ensure their best use.

The Office of Saline Water is in the process of terminating most activities devoted to seawater desalination, seawater brine disposal, operation of pilot plants, and associated environmental investigations that have previously been included in the Federal Ocean Program.

The Bureau of Reclamation is cooperating with the State of California in preliminary design and cost studies of a seafloor aqueduct to deliver water from the northern to the southern parts of the State.

In the coastal zone, the expanding National Wildlife Refuge System, administered by the Department's Bureau of Sports Fisheries and Wildlife, and the growing number of National Parks, Monuments, Seashores, and Historical Sites, maintained by Interior's National Park Service, are among the Nation's most popular tourist and vacation attractions. Between June 1971 and May 1973, Congress authorized expansion of one national monument in the coastal zone and the addition of 4 refuges, 1 national monument, 3 national seashores, and 2 recreation areas (near New York and San Francisco). The shorelines and adjacent waters of these public coastal lands provide sites for marine research by many investigators and serve as demonstration laboratories for the public.

To protect and enhance national gamefish and wildlife values, both within and outside refuges, the Bureau of Sports Fisheries and Wildlife maintains 12 fish hatcheries, is constructing 2 new ones to serve Great Lakes and marine areas, and operates five hatcheries for the National Marine Fisheries Service. The Bureau also reviews applications submitted to the Corps of Engineers for dredging and filling to assure safety of local gamefish and wildlife, and it undertakes studies and institutes control measures where habitats or associated resource values are threatened.

Department of the Interior activities that are not classified as part of the Federal Ocean Program, but which contribute to the advancement of marine science and engineering and to the development of offshore resources, include:

1. Geological Survey investigations of land resources and of geological, geochemical, geophysical, and hydrological conditions and processes that aid in identification and evaluation of potential offshore resources, and which are fundamental to recognition of natural hazards to resource development;

2. Bureau of Mines and Office of Oil and Gas studies that provide marine mineral and fossil fuel production statistics and analyses, and develop technology applicable to marine mining and ore processing;

3. Office of Saline Water general desalination and materials research that can be adapted to seawater processing and corrosion as

well as the handling of inland saline brines and contaminated water;

4. Disbursements from Interior's Land and Water Conservation Fund, administered by the Bureau of Outdoor Recreation, which provide aid to states, municipalities, and other Federal Bureaus for land acquisition and development of coastal recreation areas and facilities;

5. Assistance provided by the Bureau of Indian Affairs and Office of Territories for development of indigenous marine industries; and

6. Legal counsel and programs that relate to development of offshore resources and international law of the sea.

Environmental Protection Agency

The major mission of the Environmental Protection Agency (EPA) is to prevent, control, and abate pollution of our environment. EPA's marine science and engineering programs reflect the authorizing legislation within categories of Environmental Studies, Engineering Development, and Regulatory Activities.

In the category of Environmental Studies are programs to study the effects of pollutants of marine fish and wildlife, to study the fate of pollutants in the marine environment, to study the biological and chemical processes in the Great Lakes, to conduct comprehensive estuarine regional planning studies, to conduct technical studies of pollution conditions in support of state agencies, and support of a related data storage and retrieval system.

EPA's program on the fate of pollutants in marine waters includes studies of the processes governing transport, distribution, and chemical transformation of pollutants in marine waters. Included are investigations of the movement of heavy metals in estuarine and coastal locations, mathematical modeling to predict time-space distribution of waste discharges from barges and outfalls, and studies of the distribution of viruses, metals, and chlorinated hydrocarbons in waters and sediments of selected coastal areas. A related effort is the investigation, assessment, and modeling of local circulation patterns and other distributive forces at coastal locations, with a principal focus on the heavily used New York Bight ocean disposal sites.

EPA's role in the International Field Year for the Great Lakes (IFYGL) program is to develop and conduct the biological and chemical field studies. In FY'74, as the field studies of the IFYGL are completed, a major effort will be to develop and improve the predictive mathematical models relating the sources of pollution and the physical, chemical, and biological transport processes with the ecological effects. Efforts will be started to adapt the model for Lake Ontario to the other Great Lakes. Studies will be undertaken to develop improved guidelines and criteria for control of nutrients, heated water discharges, dredge spoils, and oil discharges, and also to assess the effectiveness of thermal and nutrient control programs.

The comprehensive coastal zone planning and management program began with studies of Monterey Bay, California, and Galveston Bay, Texas, and is being expanded to other coastal regions. The major purpose of these planning studies is to encourage conservation and environmentally optimum development of estuarine water and land resources and to develop water pollution control and abatement plans for estuarine basins and the coastal zone.

EPA's program of technical support provides assistance to State agencies upon request. The technical support staff conducts surveys of local pollution conditions normally at the request of affected States. These include surveys of polluted beaches and development of baseline data on the areas and volumes of estuaries and bays. EPA has also inaugurated a three-phase program leading to a national coastal monitoring network. The initial phases of defining requirements and available resources will be followed by the development of sampling and surveillance programs for specific coastal areas and of a national coastal monitoring network plan.

EPA's STORET system is a data processing and management facility for the collection, storage, and retrieval of water quality data obtained from a nationwide network of monitoring stations. It includes a variety of remote teleprocessing devices, digital plotting equipment, microfilm files, and digitization devices. While the primary function of STORET is the storage of physical-chemical water quality data, the system also handles data on existing and needed water treatment facilities and economic data on the cost of such facilities.

The Engineering Development Programs related to marine pollution control include programs to control and abate oil pollution, to prevent, control, and abate hazardous material spills, and to conduct estuarine and oceanographic programs.

Program emphasis of the Oil Pollution Program is on developing systems and engineering prototypes for the prevention of oil spills and the containment and recovery of oil. Specific interest is centered on the development of techniques for the removal of oil from water with the aid of sorbent materials and mechanical equipment, and the development of techniques for the restoration of oil-contaminated beaches.

Boom systems in high-velocity rivers and tidal regions, on-shore ballast treatment systems, and remote automatic oil-skimming concepts will be demonstrated. Studies of the fate and effects of oil spills in semi-tropical marine locations will receive increased emphasis.

The Hazardous Material Spills Program has as its primary objectives the development and demonstration of devices to prevent spills, the development of methods for spill reporting and emergency assessment, the development of countermeasures to lessen the

environmental damage from spills, and methods to recover spilled materials and accelerate restoration of damaged water courses.

Regulatory programs of EPA also provide direct support for marine science and engineering activities. Activities conducted in this category include the review of environmental impact statements, the establishment of water quality standards, the review of waste disposal permits, the implementation of plans to abate and control oil and hazardous industrial spills, the planned implementation of an ocean dumping permit program, and special field investigations for enforcement actions.

The major function of the Environmental Impact Statement Program is to review Environmental Impact Statements submitted by other Federal agencies. Impact statements are reviewed to ensure that water quality standards and water-related resource requirements are met, to insure that alternative actions have been properly considered, and to assess potential damage to the environment. Although statements on proposed projects throughout the Nation are reviewed, only that part of the program related to the coastal zone and the Great Lakes is included in the budgetary report.

The Water Quality Standards Program is operated in conjunction with the States and develops water quality criteria applicable to navigable waters. Plans for implementation and enforcement of the criteria are developed, and water quality standards based on consideration of their use for fish and wildlife, recreational, agricultural, and industrial purposes are established.

The Oil and Hazardous Material Implementation Program develops plans, operating procedures, and personnel training methods. It conducts operations for the surveillance, containment and removal of spilled oil and hazardous materials. EPA's program is a part of the National Contingency Plan for the control of oil and hazardous material spills. This plan provides for a coordinated response by departments and agencies of the Federal Government to protect the environment from the damaging effects of pollutant spills.

Department of State

The Department of State, with the assistance of departments and agencies of the Federal Government possessing responsibilities relating to the oceans, formulates and implements United States policy in international ocean affairs. The Department conducts negotiations with foreign governments on international ocean affairs problems on bilateral and multilateral bases, and within the forums of international organizations.

The Department is engaged in preparations for the Law of the Sea Conference, which is presently scheduled to begin its substantive work in April 1974 under the auspices of the United Nations. A series of preparatory sessions for the Conference have considered issues

including a future regime for the deep seabed; future regimes for the high seas, the continental shelf, the contiguous zone, and the territorial sea; and issues regarding marine pollution, fisheries, and the status of marine scientific research.

The Department participates in the activities of international organizations having functions that relate to the oceans. Because of the degree of technical knowledge often required for meaningful participation in these organizations, the Department often draws upon the expertise of other Federal departments and agencies possessing special competence in the area of interest of the particular international organization. An example of such an international organization is the Intergovernmental Maritime Consultative Organization, in which the United States has played a leading role in an attempt to deal with the various aspects of the problem of pollution of the marine environment from ships.

The Department:

- participates in the work of various international fisheries commissions, of which the International Commission for the Northwest Atlantic Fisheries and the International North Pacific Fisheries Commission may be cited as examples.
- provides policy guidance to the United States community conducting ocean-related activities on how such activities may affect international relations and may in turn be affected by developments in international ocean affairs.
- develops and directs the carrying out of policy recommendations regarding United States participation in international cooperative programs in marine science and technology.

Through the Agency for International Development, assistance is provided to developing nations to increase their ability to develop and utilize ocean-related resources and technologies.

Department of Health, Education, and Welfare

The Department of Health, Education, and Welfare ocean-related programs are concerned with supporting basic medical research using marine organisms, providing advice and assistance on marine health science affairs, and regulating the safety and wholesomeness of marine foods. The authority for administering these activities is primarily the Public Health Service Act and the Food, Drug, and Cosmetic Act.

The National Institutes of Health administer research contracts, grants, awards, and fellowships to medical institutions and organizations to study allergies, infectious diseases, heart diseases, arthritis, metabolic diseases, cancer, and neurological diseases. Such studies use individual and groups of marine animals and plants as experimental models in biomedical research.

The Food and Drug Administration inspects fish and shellfish-

processing establishments and examines seafood products that are shipped in interstate commerce. FDA has close cooperative activities with State and local seafood control agencies to ensure safe and healthful seafood for the consuming public. In this age of consumer protection, FDA is further improving inspection techniques and laboratory methods to detect harmful chemical and biological substances that may be in our Nation's marine food supply.

The National Marine Fisheries Service, DOC, and Environmental Protection Administration are cooperating with FDA in surveillance and monitoring of certain environmental contaminants that could enter the marine food chain and render seafood unfit for human use.

Atomic Energy Commission

The AEC marine sciences research program is directed toward determining those environmental factors which influence the movement of radioelements through the marine environment, the possible means and rates of return of radioactivity to man through marine food webs, and basic ecological processes. Within this broad program are studies on biological, physical, and chemical oceanography, and studies related to operational activities such as the impact of waste heat from nuclear power stations on local ecosystems at such sites.

The AEC supports multidisciplinary studies of nuclear power plant siting, including the environmental effects of such siting and subsequent power plant operation. The research encompasses investigation of trace element cycling, modeling of water circulation, biological production, and the effects of waste heat on ecosystems. Estuarine and coastal zone research is carried out on both the east and west coasts of the continent, including Alaska. An example of the nature of coastal zone work is the environmental study, begun in 1961, to determine the properties, distribution, and movement of Columbia River water and its dissolved and suspended load in the Northeast Pacific Ocean.

The AEC also supports research in the world oceans. Advances have been made in subjects such as circulation rates within the mixed layer of the oceans, vertical microstructure in the oceans, and abyssal water circulation.

As nuclear power plant siting in the estuarine and coastal area increases, studies must be accelerated on trace element cycling, modeling of water circulation and sedimentation, productivity at various levels of the food web, and the effects of waste heat and other non-nuclear discharges on ecosystems of the region. Insight into the physical and biological dynamics of the system is essential in order to predict the response of the marine ecosystem to man-induced stresses.

Several specific areas of research (in addition to those above) are required in problems of power plant operation for which information

is lacking. Programs must either be developed or accelerated in: (a) the toxicity to organisms of heavy metals; (b) the effects of chlorine and other anti-fouling agents contained in nuclear power plant effluents; (c) the effects on organisms from passage through the condensers of the reactors and the resultant effects on populations of organisms in the contiguous area; and (d) new designs for cooling water intake structures that will reduce the entrapment of fish and other organisms. The beneficial uses of waste heat will require increasing scrutiny.

The AEC marine sciences program will continue to stress the understanding of basic processes in the ocean related to its mission. However, recently initiated programs on effects of nuclear power plant operations and on the fate and transport of plutonium and transplutonium radionuclides will be intensified.

National Aeronautics and Space Administration

The National Aeronautics and Space Administration (NASA), through its Office of Applications, supports research and development programs concerned with the establishment of the feasibility and the demonstration of the utility of applying aerospace technology in practical ways that will prove beneficial to our Nation and to all mankind. NASA's oceanography-related activities are elements of some of these programs. These activities are primarily concerned with finding ways that remote sensing techniques, data relay techniques, and drifting buoy position location techniques can be combined with appropriate aerospace technology to satisfy the needs of Federal, State, and regional agencies for improved coastal-zone or open-ocean data acquisition and data collection systems.

As NASA has no operational role or mission in the discipline area of oceanography, NASA maintains a close cooperative working relationship with those Federal agencies that do have such roles and missions to insure that NASA's oceanographic efforts are responsive to their needs. NASA not only looks to these agencies to define their requirements for data, but also seeks their active participation in the planning and conduct of experiments in the field. NASA depends heavily on other agencies to provide the oceanographic data obtained by conventional techniques that are required by NASA to ascertain how well the remote sensor data obtained during aircraft or earth-orbiting spacecraft flights do correlate with the oceanographic parameters, processes, or phenomena being observed, measured, or monitored from space.

NASA's oceanographic research activities fall into three categories: (1) remote sensor design, development, and validation testing; (2) the development of computer software for handling the processing and formatting of remote-sensor-derived oceanographic data so as to facilitate the interpretation and use of the data by the other agencies; (3) and the design, development, and evaluation

testing of techniques for collecting oceanographic data obtained by unattended instruments on moored and drifting buoys through a satellite data relay link to a shore-based data processing facility, and for determining the position of drifting buoys.

NASA makes use of aircraft and unmanned or manned earth-orbiting spacecraft in conducting performance evaluation experiments. The aircraft program is used to provide platforms for remote sensing instrumentation undergoing performance tests, and for acquiring oceanographic data at times of satellite overflights of regions where it was not possible to have ships acquire the desired data for correlation with the satellite-sensor-derived data.

Experiments are being carried out with a larger array of remote sensor instrumentation which will enable NASA to gain further insight into the usefulness of multi-spectral visible, infrared, and microwave remote sensing techniques in acquiring oceanographic data of interest to Federal, State, and regional agencies. Precision pulsed-radar altimeters are also being investigated for the purpose of making an assessment of the application of geodetic satellite technology and precision distance measurement techniques to the acquisition of data about the dynamic topography of the ocean surface, with sufficient accuracy to allow an improved determination of mean sea level and deviations of the ocean surface from mean sea level associated with open ocean tides, geoidal undulations, and global oceanic circulation.

Smithsonian Institution

The marine science activities of the Smithsonian Institution involve the systematics and ecology of marine organisms and investigations of biological and geological phenomena of marine environments. Support services are provided in sampling, sorting, identification, curation, and data management of natural history specimens.

The National Museum of Natural History (NMNH) maintains the largest collection of biological specimens and geological samples in the world. These collections are actively being studied by scientists and constitute an important resource for research on current and historical environmental conditions.

Research projects are individual efforts, or team enterprises involving scientists from several departments within the museum and from other institutions from the U.S. and abroad. Projects vary considerably in scope and emphasis, but almost always include systematic analysis of organisms being studied, often on a monographic scale, based on collections which have been made for a multitude of purposes. Logical adjuncts of the systematic work include zoogeographic analyses and correlation with relevant physical data, preparation of annotated checklists, ecological research aimed at determining relationships between organisms and

their environment, and short-to-long-term monitoring of areas, populations, or biota.

The Smithsonian Oceanographic Sorting Center (SOSC) is a service unit of the Smithsonian Institution operated by the Oceanography and Limnology Program. Acting as a central processing laboratory, SOSC receives, sorts, records, curates, and distributes marine as well as freshwater collections in order to efficiently and accurately make these collections available to specialists. In addition to these services, SOSC performs analyses of biological samples through the computer facilities of its Records Section and the data are prepared in a machine-readable and rapidly retrievable form.

Patterned after the Smithsonian Oceanographic Sorting Center and maintained in Tunisia through the use of P.L. 480 excess currency funds, the Mediterranean Marine Sorting Center (MMSC) processes marine biological specimens from the Mediterranean Sea. In addition to providing sorting services, the MMSC serves an important function in the training of marine technicians from developing countries throughout the Mediterranean region.

The Chesapeake Bay Center for Environmental Studies is conducting long-term ecosystem study of the Rhode River estuary, involving scientists from the National Museum of Natural History, the Radiation Biology Laboratory, and various institutions. The goal of this research program is to determine the effects of environmental fluctuations on ecosystem stability. These investigations will help identify those parameters most sensitive to changes in environmental conditions, and also improve our understanding of the causal relationships in such systems, which is required for successful environmental prediction. Research projects include ground-truth evaluation of remote sensing and other aerial photographic techniques.

The Smithsonian Tropical Research Institute (STRI), located in Panama, has a fourfold program: research on basic biological processes, support of advanced training and higher education through research, support of research in the tropics by others, and work on behalf of conservation in the tropics. While encouraging collection of data on tropical biota and environments, biologists of STRI and many other visiting scientists focus attention on such subjects as the establishment of reproductive isolation among related species, the ecology of coral reefs, species diversity in different parts of both the New and Old World tropics, effects of oil pollution, ramifications of an interoceanic canal, parasitism, mimicry, predator-prey strategies, and mathematical theories of evolution and community ecology.

The Fort Pierce Bureau is a recently-established facility of the Smithsonian Institution at Link Port, located on the Indian River between Fort Pierce and Vero Beach, Florida. A primary mission of

the Bureau is to perform research using facilities developed through support by the Harbor Branch Foundation and the Atlantic Foundation.

The Center for Short-Lived Phenomena is involved in several programs in marine science. Through its international network of over 3,000 correspondents in 144 countries, the Center reports major short-lived marine events such as oil spills and other toxic substance contamination, sub-marine volcanic eruptions, island eruptions, earthquakes and tsunamis, unusual marine biota events such as fish kills, red tides, bioluminescence plankton blooms, sea animal migrations and strandings, storm surges, floods, and severe storm erosion.

Oceanographic research information has been registered at Smithsonian Science Information Exchange (SSIE) since 1961. In 1968, the National Council on Marine Resources and Engineering Development designated SSIE to be the national information center for unclassified current marine science research information. Specifically, the Exchange undertook the responsibilities of a national center for receiving, compiling, cataloguing, and disseminating information concerning unclassified ongoing research and development activities in the marine sciences.

APPENDIX C—THE NATIONAL SEA GRANT PROGRAM

The National Sea Grant Program is the principal national instrument for carrying out cooperative programs in the coastal zone and oceans with State and local governments, academic institutions, and industry for the purpose of fostering marine resource development, technology, environmental research, education and training, and advisory services. These broad programs are organized to function under several interlocking activities, each with specific goals as follows:

Marine Resources Development and Utilization—to assist and accelerate the development of new marine business and increase the efficiency of existing industry through research, engineering, and assessment of socio-economic and legal implications, relating to the propagation, utilization, and management of specific living marine resources and their products, mineral resources including fuels, and recreation.

Socioeconomic and Legal Studies—To acquire information and develop appropriate evaluation and study techniques for the identification and assessment of relevant economic factors over specific areas in the coastal zone, investigation of basic institutional establishments, review of legal requirements, and development of new legal concepts.

Marine Technology—To facilitate through engineering the development of new industry and the improvement of the general efficiency and productivity of existing industry; to better man's ability to operate in the marine environment; and to help control and correct the adverse effects of natural forces and man's activities on the coastal zone and its marine resources.

Marine Environmental Research—To develop through research the basic knowledge needed both to formulate coastal zone management plans and to assist coastal zone managers in making sound decisions for assuring an optimum mix of development, conservation, and management of the coastal environment and its marine resources.

Marine Education and Training—To educate and train the specialized manpower needed to meet national marine objectives, with due prudence to avoid an excess supply of manpower in fields of presently or potentially adequate supply.

Marine Advisory Service—To organize an integrated program of marine advisory and extension services so that scientific and technical research results may be transferred to ultimate users as rapidly as possible; to provide a feedback mechanism through which the real concerns and problems of marine users may be communicated most expeditiously to the research community.

During its short lifetime, Sea Grant has grown from a program of \$5.0 million in FY '68 to \$19.5 million in FY '73. Some 1790 scientists and engineers from more than 100 institutions have engaged in about 600 different projects, while 1,670 students are enrolled in its programs, and 100 companies are affiliated with it. Six institutions have thus far earned the designation of "Sea Grant College".

SEA GRANTS

Type of Grant	Number of Grants	
	FY 1972 Actual	FY 1973 Actual
Project Grants	28	26
Institutional Grants	30	15
Total Sea Grants	58	41

SEA GRANT COLLEGES

University of Rhode Island	University of Washington
Texas A&M University	University of Hawaii
Oregon University	University of Wisconsin

SEA GRANT

Expenditures by Major Topic and Fiscal Year

[Dollars in Thousands]

	FY '72 Actual	FY '73 Estimated	FY '74 Estimated
I. Marine Resources Development	5643	5940	4750
II. Marine Socio-Economic and Legal Research	727	820	900
III. Marine Technology Research and Development	3038	2900	5106
IV. Marine Environmental Research	2967	4200	4115
V. Marine Education and Training	3252	2000	1950
VI. Marine Advisory Services	1645	2960	2000
VII. Program Management	405	680	679
TOTAL	17,677	19,500	19,500

SEA GRANT

Expenditures by State and Institution for FY 1972

[Dollars in Thousands]

State	Institution	Amount
Alaska	University of Alaska	350
California	Humboldt State College	166
	Santa Barbara City College	56
	University of California, Davis	5
	University of California, San Diego	1,335
	University of Southern California	575
	Department of Navigation and Ocean Development	14
	Sub-Total	2,151
Connecticut	University of Connecticut	85
Delaware	University of Delaware	600
Florida	State University System of Florida	308
	University of Miami	88
	Sub-Total	396
Hawaii	University of Hawaii	1,269
	Oceanic Institute	38
	Sub-Total	1,307
Louisiana	Louisiana State University	616
Maine	Maine Department of Sea and Shore	75
	Maine Maritime Academy	10
	University of Maine	151
	Sub-Total	236
Maryland	University of Maryland	12
Massachusetts	Massachusetts Institute of Technology	625
	Woods Hole Oceanographic Institution	267
	Sub-Total	892
Mississippi	University Marine Center	314
New Hampshire	University of New Hampshire	420
New Jersey	Stevens Institute of Technology	70
New York	Columbia University (Lamont-Doherty)	384
	Nassau-Suffolk Regional Planning Board	40
	State University of New York	600
	University of Rochester	9
	Poseidon Scientific Corp.	10
	Sub-Total	1,043
North Carolina	Cape Fear Technical Institute	381
	University of North Carolina	730
	Sub-Total	1,111
Ohio	Kent State University	73
Oregon	Oregon State University	1,700
Pennsylvania	Lehigh University	182
Rhode Island	University of Rhode Island	1,125

SEA GRANT—Continued
Expenditures by State and Institution for FY 1972—Continued

[Dollars in Thousands]

State	Institution	Amount
South Carolina	Department of State of South Carolina	213
Texas	Texas A&M University	1,442
Virginia	Virginia Institute of Marine Sciences (VIMS)	325
	Virginia Polytechnic Institute (VPI)	53
	Sub-Total	378
Washington	University of Washington	1,367
Wisconsin	University of Wisconsin	1,000
District of Columbia	Washington Technical Institute	92
Trust Territories in the Pacific	Marine Research Division of Trust Territories	8
Virgin Islands	College of the Virgin Islands	6
	Total	17,189
	Program Management	488
	GRAND TOTAL	17,677

APPENDIX D—THE INTERNATIONAL DECADE OF OCEAN EXPLORATION

In 1969 the National Science Foundation was assigned responsibility for the planning, management, and funding of the United States contribution to the International Decade of Ocean Exploration. From the outset emphasis has been upon international cooperation in research important in man's use of the oceans and its resources, as well as on the impact of his activities on the oceans and the impact which the oceans have on man's activities.

The IDOE philosophy is that major strides in man's use and understanding of the oceans depends on knowledge derived from sustained, comprehensive research projects directed at specific problems. Fruitful advances in understanding the areas singled out for special attention by the IDOE are most likely when carried out by teams of scientists from many disciplines, institutions, and countries. Presently, the IDOE supports ten large-scale, interdisciplinary projects in Environmental Quality, Environmental Forecasting, Seabed Assessment, and Living Resources.

The Environmental Quality Program is designed to assess, understand, and predict man's impact on the marine environment. Studies are supported to determine present-day concentrations of pollutants and trace compounds in the environment, and to provide knowledge about sources and rates of input, dispersal and transfer mechanisms, and effects on organisms of pollutants in the oceans. One major project (Geochemical Ocean Sections Study—GEOSECS) will provide knowledge of processes important to the diffusion, mixing, and dispersion of trace compounds and contaminants on an ocean-wide basis.

The Environmental Forecasting Program seeks to develop improved physical and mathematical models of the ocean and air-sea coupling that will provide the basis for increased accuracy in describing and predicting the oceanic environment. Major projects include comprehensive studies of large-scale ocean-atmosphere interactions (the North Pacific Experiment—NORPAX), mid-ocean dynamics (Mid-Ocean Dynamics Experiment—MODE), and paleo-oceanography (Climate—Long-range Investigation, Mapping, and Prediction—CLIMAP).

The Seabed Assessment Program supports studies of the continental margins, deep-sea floor, and mid-oceanic ridges to identify new areas of natural resources, particularly petroleum and

hard minerals, and to enhance understanding of the natural processes which produce these resources. Studies are being conducted on both the African and South American margins of the Atlantic, on the margins of the Nazca crustal plate adjacent to the west coast of South America, and on the mid-Atlantic Ridge.

The Living Resources Program strives to provide a scientific basis for improved management and use of the ocean's living resources. Research efforts rely on the use of advanced methods in the biological, chemical, and physical marine sciences to make an intensive effort to understand marine ecosystems. Effort is focused on a comprehensive study of physical, chemical, and biological processes in coastal upwelling ecological systems.

INTERNATIONAL DECADE OF OCEAN EXPLORATION

Funding by Program Area

[Dollars in thousands]

	Actual FY 1972	Estimate FY 1973	Estimate FY 1974
Environmental Forecasting	8,651	5,900	4,000
Environmental Quality	5,840	5,000	6,000
Seabed Assessment	3,790	4,100	4,000
Living Resources	1,070	1,800	2,500
General Support	320	400	500
Total	19,671	17,200	17,000

U.S. IDOE PARTICIPANTS

ACADEMIC

University of Alaska	Massachusetts Institute of Technology
Brown University	University of Miami
California Institute of Technology	Nova University
University of California, San Diego	Oregon State University
University of California, Berkeley	Puerto Rico Nuclear Center
University of California, Los Angeles	Queens College
Columbia University	Rice University
University of Connecticut	University of Rhode Island
Duke University	University of Southern California
Harvard University	Texas A&M University
University of Hawaii	University of Texas
University of Georgia (Skidaway)	Woods Hole Oceanographic Institution
Johns Hopkins University	Yale University
Lamont-Doherty Geological Observatory	

GOVERNMENTAL

Atomic Energy Commission
National Bureau of Standards
Atlantic Oceanographic and Meteorological Laboratories (NOAA)
Pacific Oceanographic Laboratory (NOAA)
National Marine Fisheries Service (NOAA)
Geophysical Fluid Dynamics Laboratory (NOAA)
Environmental Data Service (NOAA)
National Oceanographic Instrumentation Center (NOAA)
Smithsonian Institution

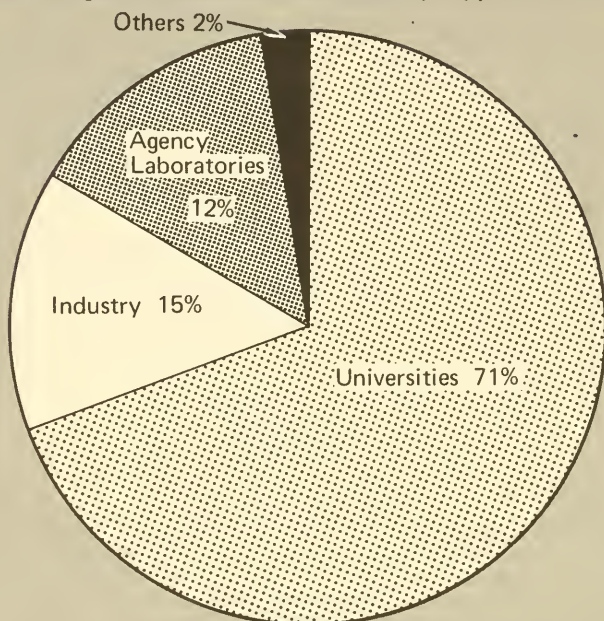
NONPROFIT AND INDUSTRY

American National Standards Institute
Battelle Northwest
National Academy of Sciences
National Academy of Engineering
General Dynamics

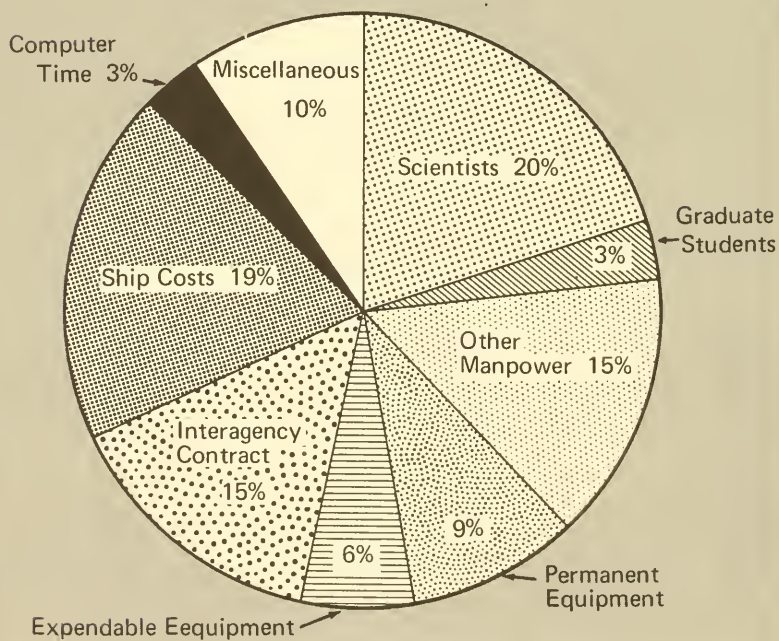
COUNTRIES COOPERATING IN THE IDOE PROGRAM

Argentina	Germany (Federal	Peru
Australia	Republic of)	Portugal
Bolivia	Ghana	Senegal
Brazil	Iceland	Sierra Leone
Canada	India	Singapore
Chile	Italy	South Africa
Columbia	Jamaica	Spain
Congo	Japan	Sweden
Denmark	Liberia	Switzerland
Ecuador	Mexico	Union of Soviet
France	Netherlands	Socialist Republics
Gabon	Nigeria	United Kingdom
	Norway	

Percentage Distribution of Funds By Type of Performer



Percentage Distribution of Funds By Manpower and Other Factors



APPENDIX E—A SELECTION OF LAWS AFFECTING MARINE ACTIVITIES; 92nd CONGRESS

This listing provides only a summary of selected laws. It is not published for use in determining their impact on Federal programs. For that purpose, an analysis of the full text of each law in the context of all applicable legislation would be required.

1st Session

1. P.L. 92-63 (S. 699) August 4, 1971. The Vessel Bridge-to-Bridge Radiotelephone Act.

This Act will require vessels, dredges, and floating plants to be equipped with short-range, bridge-to-bridge radiotelephones for the exchange of navigational information for the prevention of collisions as follows: (1) every power-driven vessel of 300 gross tons and upward while navigating; (2) every vessel of 100 gross tons and upward carrying one or more passengers for hire while navigating; (3) every towing vessel of 26 feet or over in length while navigating; and (4) every dredge and floating plant engaged in or near a channel or fairway in operations likely to restrict or affect the navigation of other vessels. The radiotelephone will have to be capable of transmitting and receiving on the frequency or frequencies within the 156-162 mega-hertz band, using classes of emissions designated by the Federal Communications Commission.

2. P.L. 92-75 (H.R. 19) August 10, 1971. The Federal Boat Safety Act of 1971.

This Act authorizes the Secretary of the Department in which the Coast Guard is operating to issue regulations and standards for the manufacture and the safe operation of recreational boats; approve State boating safety programs; and make grants-in-aid to the States to assist in carrying out their boating safety programs. Provisions for enforcement are included, and an authorization for the appointment of a National Boating Safety Council of representatives of States, local governments, industry, boating organizations, and the general public to consult with the Secretary on boating safety matters.

3. P.L. 92-87 (H.R. 9181) August 11, 1971. An Act to amend the Northwest Atlantic Fisheries Act of 1950.

The purpose of this Act is to bring the Northwest Atlantic Fisheries Act of 1950, as amended, into accord with two new Protocols to the International Convention for the Northwest Atlantic Fisheries. One of these Protocols simplifies the entry into force of proposals from the International Commission for the Northwest Atlantic Fisheries (ICNAF), pursuant to its authority under the Convention. The other Protocol authorizes the Commission to propose international measures of control (enforcement) that would insure uniform application of conservation regulations established by the Commission.

In addition, the Act authorizes the Secretary of State, in consultation with the Secretary of Commerce, to designate Alternate U.S. Commissioners to attend meetings of the International Commission for the Northwest Atlantic Fisheries.

4. P.L. 92-125 (H.R. 2587) August 16, 1971. The National Advisory Committee on the Oceans and Atmosphere.

This Act establishes a committee of twenty-five members to be known as the National Advisory Committee on Oceans and Atmosphere. The members are appointed by the President from State and local government, industry, science, and other appropriate areas, but may not be full-time officers or employees of the United States.

The Advisory Committee will carry on a continuing review of the progress of the marine and atmospheric science and service programs of the United States and advise the Secretary of Commerce with respect to carrying out the purposes of the National Oceanic and Atmospheric Administration. Annual reports will be made to the President and the Congress concerning the status of the Nation's marine and atmospheric activities and such special reports as the President may request.

The Act authorizes the Secretary of Commerce to make available to the Committee such staff, information, personnel, and administrative services as may be reasonably required and provides an authorization for an appropriation of \$200,000 annually for support of the activities of the Committee.

5. P.L. 92-163 (H.R. 155) November 23, 1971. An act to facilitate the transportation of cargo by barges specifically designed for carriage aboard a vessel.

This act clarifies the conditions under which cargo may be carried aboard barges which are in turn regularly carried by vessels. It also establishes the reciprocal privileges which foreign governments

must extend to vessels of the United States for operation of barges aboard ships.

6. P.L. 92-219 (H.R. 3304) December 23, 1971. An Act to amend the Fisherman's Protective Act of 1967 to enhance the effectiveness of international fishery conservation programs.

This Act adds a new section to the Fisherman's Protective Act of 1967, giving the President discretionary authority to prohibit the importation of fishery products from nations which conduct fishing operations in a manner that diminishes the effectiveness of any multilateral international fishery conservation program in which the United States participates. The Secretary of Commerce has the responsibility under the Act for certifying to the President when such fishing operations are being conducted by foreign nations.

The Secretary of the Treasury is responsible for instituting and enforcing any embargo the President elects to apply. The terms of the Act provide that the President shall notify the Congress of any action taken 60 days following certification by the Secretary of Commerce. If the President, after the certification, fails to direct the Secretary of the Treasury to prohibit the importation of fish products of the offending country, or if the prohibition does not include all fish products of the offending country, the President shall inform the Congress of the reasons therefor.

2nd Session

7. P.L. 92-340 (H.R. 8140) July 10, 1972. The Ports and Waterways Safety Act of 1972.

This Act is designed to cope with the increasing safety hazards of maritime transportation and with the pollution problems resulting from operation and casualties of vessels carrying oil or other hazardous substances in bulk. It is designed to protect the coastal waters and the living resources as well as recreational and scenic values.

The Secretary of the Department in which the Coast Guard is operating is authorized to develop certain control procedures and regulations designed to result in safer operation of vessels in order to prevent damage or loss of any vessel, bridge, or other structure on or in the navigable waters of the United States, or any land structure or shore area immediately adjacent to these waters. These protective measures will also cover the waters and the living resources themselves.

8. P.L. 92-402 (H.R. 13324) August 22, 1972. An Act to authorize appropriations for the fiscal year 1973 for certain maritime programs of the Department of Commerce.

This Act is the Maritime Appropriations Act, but it also authorizes the Secretary of Commerce to transfer certain Liberty ships, otherwise scheduled to be scrapped, to States for use as offshore artificial reefs for the conservation of marine life. A State would apply for these surplus Liberty ships in accordance with regulations to be prescribed by the Secretary of Commerce. Information on the locations where the State proposes to sink the ships and the conservation goals sought to be achieved would be required to be included in such application. Prior to taking any action, the Secretary of Commerce would provide copies of the application to the Secretary of the Interior, the Secretary of the Army, and any other appropriate Federal officers, and obtain their comments and views. If the Secretary of Commerce finds, after obtaining the views of other appropriate Federal officials, that such use of these Liberty ships does not violate Federal law and is not frivolous, and the State agrees to the required terms and conditions, including the furnishing of assurances that the vessels will be used for the stated purposes, he would be authorized to transfer without consideration to the applicant State all right, title, and interest of the United States in such vessels.

9. P.L. 92-444 (H.R. 12207) September 29, 1972. The Central, Western, and South Pacific Fisheries Development Act.

This Act authorizes a program for the development of fishery resources in the Central, Western, and South Pacific Ocean. The legislation authorizes the Secretary of Commerce to undertake, either directly or by contract, a three-year program for the development of the tuna and other latent fisheries resources of the Central, Western, and South Pacific Ocean. Included in the program are exploration for and stock assessment of tuna and other fish, improvement of harvesting techniques, gear development, biological resource monitoring, and an economical evaluation of the potential for tuna and other fisheries in such areas. During the first year, the program will include exploration by large, modern purse seiners and various size bait boats and the use of aircraft to assist in spotting fish schools. The results of these explorations will be reviewed and reported by the Secretary and used to develop the program for the second and third years. The sum of \$3 million is authorized to carry out the purposes of the Act and will remain available until expended.

10. P.L. 92-471 (H.R. 9501) October 9, 1972. An Act to amend the North Pacific Fisheries Act of 1954.

This Act amends the North Pacific Fisheries Act of 1954, which implements the International Convention for the High Seas Fisheries of the North Pacific Ocean. It provides that the United States shall be represented on the International North Pacific Fisheries

Commission by not more than four Commissioners to be appointed by the President. After January 1, 1973, each U.S. Commissioner shall be appointed for a term not to exceed four years, but is eligible for reappointment, and may be appointed for a lesser term to insure that only one Commissioner's term will expire in any given year.

The Act further provides for mandatory, rather than discretionary, payment of expenses for a limited number of advisers to the Commission.

In addition, it permits the Secretary of State, in consultation with the Secretary of Commerce, to designate Alternate Commissioners so that in the event of the absence of a regularly appointed Commissioner, the United States will be assured of full representation at meetings of the Commission. Alternate Commissioners can also be designated for other specified international commissions. The Act also makes certain corrections and clarifications which had become desirable as the result of changed circumstances.

11. P.L. 92-500 (S. 2770) October 18, 1972. Federal Water Pollution Control Act Amendments of 1972.

This Act proposes a major change in the enforcement mechanism of the Federal water pollution control program from water quality standards to effluent limits. Among other things, it requires the best practicable technology to be in use by 1977 and specifically requires zero discharge if it is technologically and economically achievable. It is a very far-reaching bill with considerable sums of money involved.

12. P.L. 92-504 (H.R. 16870) October 18, 1972. An amendment to the Sockeye Salmon or Pink Salmon Fishing Act of 1947.

This Act authorizes the appropriation of \$7 million for the U.S. share of funds required for the restoration and extension of the sockeye and pink salmon runs of the Fraser River system. The money granted to the International Pacific Salmon Fisheries Commission for their use in constructing 12 spawning channels over a period of 16 years.

13. P.L. 92-507 (H.R. 9756) October 19, 1972. The Federal Ship Financing Act of 1972.

This Act would amend the Merchant Marine Act of 1936, as amended. The Purpose of the Act is to expedite procedures relating to vessel mortgage guarantees, simplify paperwork, and better meet current industry needs for investment capital. This legislation would broaden the time limits on the use of Government assisted financing and provide refinancing authority enabling vessel owners to convert to financing with longer maturities and/or lower interest

rates, making additional resources available for modernization and expansion of the domestic fleet.

14. P.L. 92-522 (H.R. 10420) October 21, 1972. The Marine Mammal Protection Act of 1972.

The Act would conserve and protect marine mammals by imposing a permanent moratorium, subject to certain exemptions and exceptions, on their taking and importation. A permit system is provided for most allowed takings and importations pursuant to regulations. Restrictions are imposed on any taking and importing allowed under the Act.

The Act applies to all persons and vessels subject to the jurisdiction of the United States. It is to be administered by the Secretary of Commerce with respect to whales, porpoises, seals, and sea lions, and the Secretary of the Interior for sea otters, walruses, manatees, and polar bears.

The taking of marine mammals by Aleuts, Indians, and Eskimos is exempted from the Act if done for subsistence purposes or handicrafts. The Secretary can also exempt any person for up to one year on grounds of economic hardship. The Pribilof fur seal harvest is exempt.

The following exceptions also are permitted under the permanent moratorium:

(1) A 2-year exemption for mammals taken incidental to commercial fishing operations, in accordance with regulations. Thereafter, incidental taking is allowed subject to the permit system.

(2) Takings or importations for scientific or public display purposes under permits.

(3) Taking or importations as to which the Secretary has waived the moratorium and for which permits have been issued.

The Act creates the Marine Mammal Commission and the Committee of Advisors and sets forth the duties of those bodies.

15. P.L. 92-532 (H.R. 9727) October 23, 1972. The Marine Protection, Research, and Sanctuaries Act of 1972. (the "ocean dumping" bill)

This Act would regulate the transportation from the United States of material for dumping into the oceans, coastal, and other waters, and the dumping of material from any source into waters over which the United States has jurisdiction.

In Title I of the Act, the Administrator of the Environmental Protection Agency would be empowered to issue permits for transportation or dumping where he determines that it will not

unreasonably degrade or endanger human health, welfare, or amenities, or the marine environment, ecological systems or economic potentialities. Various specified factors including the effect of such dumping on fisheries resources, marine ecosystems, and the effect on alternate uses of the oceans, such as scientific study, fishing, and other living resource exploitation, would be considered in issuing a permit.

The Secretary of the Army would similarly be empowered to issue permits for transportation or dumping of dredged or fill material with respect to projects undertaken directly by or under contract with the Corps of Engineers.

In Title II of the Act, the Secretary of Commerce, in coordination with the Secretary of the Department in which the Coast Guard is operating and with the Administrator of the Environmental Protection Agency, would initiate a comprehensive and continuing program of research regarding the effects of ocean dumping.

In addition, the Secretary of Commerce in consultation with other appropriate Federal Departments, agencies, and instrumentalities, would initiate a comprehensive and continuing program of research with respect to the possible long-range effects of pollution, over-fishing, and man-induced changes of ocean ecosystems.

Finally, in Title III of the Act it provides for the designation of marine sanctuaries by the Secretary of Commerce for, among other things, the protection of coastal and offshore areas for their conservation, recreational, ecological, and aesthetic values.

16. P.L. 92-567 (H.R. 15280) October 25, 1972. An Act to amend the Act of August 16, 1971, which established the National Advisory Committee on Oceans and Atmosphere.

This Act increases the appropriation authorization under the original Act. This Act increases the authorized appropriation to the Secretary of Commerce from \$200,000 to \$400,000 for each of the fiscal years 1973, 1974, and 1975.

17. P.L. 92-569 (H.R. 7117) October 26, 1972. An Act to amend the Fishermen's Protective Act of 1967.

This Act would provide procedures designed to expedite reimbursement to owners of U.S.-flag fishing vessels for certain expenses in the form of fines, license fees, or other such charges incurred as a result of illegal seizures and would amend and strengthen the provisions for seeking collection of such reimbursed amounts from the foreign countries involved in such seizures.

18. P.L. 92-583 (S. 3507) October 27, 1972. The Coastal Zone Management Act of 1972.

The Act establishes a national policy and initiates a national program for the management, beneficial use, protection, and development of the Nation's coastal zones (generally, the submerged lands and waters of the territorial sea and the adjacent shorelands having a direct and significant impact on such waters).

The Department of Commerce, charged with the administration of the Act, will:

- (1) make planning grants and implementing grants of up to two-thirds of the cost of creating and administering individual State coastal zone management programs which meet the criteria of the Act;
- (2) provide a continuing review of coastal State performance under approved management programs and terminate financial assistance upon an unjustified failure to adhere to the program;
- (3) carry out extensive consultation and coordination with all Federal agencies on management programs prior to their approval;
- (4) make Federal grants to States of up to 50 percent of the cost of acquiring, developing, and operating estuarine sanctuaries;
- (5) report annually to Congress on activities under the Act, including a statement as to Federal agency actions or projects which are not consistent with approved management programs;
- (6) develop and promulgate rules and regulations to implement the Act.

Before the Secretary of Commerce can approve a coastal zone program, he is required to obtain the concurrence of any Federal agency administering a federally supported national land use policy program over affected inland areas. Implicitly, NOAA has the responsibility to assist the States by developing an adequate environmental data base for each coastal state.

Funds are authorized for fiscal year 1973 to assist the States in establishing and administering coastal zone and estuarine management programs.

19. P.L. 92-590 (S. 3524) October 27, 1972. An Act to extend the provisions of the Commercial Fisheries Research and Development Act of 1964, as amended, (P.L. 88-309).

The purpose of the legislation is to coordinate State-Federal efforts in research and development for the conservation of the commercial fishery resources of the Nation, as well as the environment that supports them, by authorizing Federal assistance for State programs meeting Federal approval.

In accomplishing this purpose, the legislation would authorize to

be appropriated \$5 million per year to carry out section 4(a) of the Act, \$1.5 million per year to carry out section 4(b) of the Act, and \$100,000 per year to carry out section 4(c) of the Act. In addition, the legislation would extend the life of the program for an additional 5 years—from July 1, 1973 to June 30, 1978.

20. P.L. 92-594 (S. 3545) October 27, 1972. An Act to amend section 7 of the Fishermen's Protective Act of 1967.

This Act would extend the provisions of section 7 until July 1, 1977. Such extension would continue a program of reimbursing certain losses and costs other than fines, license fees, or other such charges incurred by owners as a result of the seizure of United States flag fishing vessels by foreign countries on the basis of claims not recognized by the United States. In addition, the bill would transfer the administration of the program authorized by the act from the Secretary of the Interior to the Secretary of Commerce pursuant to the provisions of Reorganization Plan No. 4 of 1970.

21. P.L. 92-601 (S. 3358) October 27, 1972. An Act to prohibit the use of certain small vessels in the United States fisheries.

This Act would prohibit certain vessels under five net tons from landing certain species of fish in a port of the United States. The bill would limit the ability of such vessels to fish in the territorial sea or the contiguous zone for certain species of fish. The effect of the bill would be that small foreign-built fishing boats which have been prohibited from a fishery of a foreign country would not be permitted to enter a similar fishery of the United States. Specifically, it would be unlawful for any person on board any prohibited vessel to transfer at sea or cause to be transferred at sea any prohibited fish or to land or cause to be landed any prohibited fish in any port of the United States. It would also be unlawful for any person to take, sell, transfer, purchase, or receive any prohibited fish which are transferred or landed in violation of this Act or to violate any regulation issued under this Act.

22. P.L. 92-604 (H.R. 16074) October 31, 1972. An Act to authorize appropriations to carry out jellyfish control programs.

This Act would extend until June 30, 1977, the program to provide for the control or elimination of jellyfish and other such pests in the coastal waters of the United States and authorize \$400,000 per year.

APPENDIX F—SELECTED LIST OF MARINE SCIENCE AND RELATED PUBLICATIONS, 1971-72.

A Description and Analysis of Coastal Zone and Shoreland Management Programs in the United States; Technical Report No. 20; The University of Michigan (Sea Grant Program), (March 1972)

Alpha Helix Research Program, 1971; University of California, San Diego

Annual Report, June 1, 1971-May 31, 1972; Chesapeake Research Consortium, Inc., Johns Hopkins University, (1972)

*A report to: *The President and the Congress*, by the National Advisory Committee on Oceans and Atmosphere-First Annual Report; (July 30, 1972)

Baseline Studies of Pollutants in the Marine Environment and Research Recommendations; International Decade of Ocean Exploration, Baseline Conference, National Science Foundation, (May 1972)

CICAR Bibliography, Vol. II, Marine Biology, and Vol. III, Marine Geology and Geophysics; National Oceanographic Data Center, National Oceanic and Atmospheric Administration, Department of Commerce, (1972)

The Coastal Zone of Delaware, The Final Report of the Governor's Task Force on Marine and Coastal Affairs; College of Marine Studies, University of Delaware, (April 1970-October 1971)

Coastal Mapping Symposium; (Proceedings of a Symposium on Coastal Mapping); American Society of Photogrammetry, Falls Church, Virginia, (June 1972)

The Columbia River Estuary and Adjacent Ocean Waters; Atomic Energy Commission, (Published by University of Washington Press, 1972).

**Compilation of Federal Laws Relating to Conservation and Development of our Nation's Fish and Wildlife Resources, Environmental Quality, and Oceanography*; Committee on Commerce, United States Senate, Legislative Reference Service, The Library of Congress, (April 1971)

Detection of Oil Concentration in Sea Water; Maritime Administration, Department of Commerce (April 1971)

Development of National Data Buoy Systems; National Data Buoy Center, National Ocean Survey, Department of Commerce, (May 1972)

**Engineering Economic Model for Fish Protein Concentration Processes*; NOAA Technical Report NMFS CIRC-367; National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Department of Commerce, (October 1972)

Environmental Effects of Overboard Discharge of Biodegradable Wastes in the Open Ocean; The Oceanographer of the Navy, (November 1971)

See footnote at the end of Appendix F.

- Environmental Guide for the U.S. Gulf Coast*; Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Data Service, National Climatic Center, (November 1972)
- Environmental Guide for Seven U.S. Ports and Harbor Approaches*; Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Data Service, National Climatic Center (February 1971)
- The Evolving Role of the Federal Government in the Management of Lake Michigan*; Sea Grant Technical Report No. 24; School of Natural Resources—The University of Michigan (May 1972)
- Feasibility of a North Atlantic Deep-Water Oil Terminal*; Maritime Administration, Department of Commerce (July 1972)
- **Exploiting the Resources of the Seabed*; Subcommittee on National Security Policy and Scientific Developments; Committee on Foreign Affairs, U.S. House of Representatives; Congressional Research Service, Library of Congress (July 1971)
- Final Environmental Impact Statement, Proposed Trans-Alaska Pipeline; Environmental Setting of Marine Routes, Vol. 3*, Department of the Interior (1972)
- **The Federal Ocean Program*; Office of Science and Technology; Executive Office of the President (April 1972)
- **Federal Plan for Marine Environmental Prediction, Fiscal Year 1973*; Department of Commerce, National Oceanic and Atmospheric Administration, Interagency Committee for Marine Environmental Prediction (March 1972)
- First Annual Report of UNOLS Advisory Council to Federal Funding Agencies; University—National Oceanographic Laboratory System, Woods Hole, Massachusetts* (July 1972)
- **Fishery Publications, Calendar Year 1971: Lists and Indexes*; Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, NOAA Technical Report NMFS CIRC-372 (October 1971)
- Floatable Oily Waste Treatment System—Feasibility Study*; Maritime Administration, Department of Commerce (June 1971)
- Grant-in-Aid for Fisheries Program Activities-1972*; National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Department of Commerce (July 1971)
- International Decade of Ocean Exploration*; National Science Foundation (October 1971)
- International Inventory and Forecast of Offshore Petroleum and Mineral Activity-Final Report*; United States Coast Guard, Department of Transportation (February 1973)
- Marine Environmental Quality (Suggested Research Programs for Understanding Man's Effect on the Ocean)*; National Academy of Sciences (August 1971)
- Marine Geophysical Data Catalog: A Key to Geophysical Records Documentation #1*; National Oceanographic Data Center, National Oceanic and Atmospheric Administration, Department of Commerce (June 1972)

See footnote at the end of Appendix F.

Mineral Resources Off the Northeastern Coast of the United States; U.S. Geological Survey, Department of Interior (1972)

National Shoreline Study—Shore Management Guidelines; Department of the Army, Corps of Engineers (August 1971)

**National Science Foundation Grants and Awards 1972*; National Science Foundation, NSF 73-2 (1973)

**Ocean Disposal of Barge-Delivered Liquid and Solid Wastes from U.S. Coastal Cities*; Environmental Protection Agency (1971)

Oily Water Separation Systems; Maritime Administration, Department of Commerce (January 1972)

**Patterns of Energy Consumption in the United States*; Office of Science and Technology, Executive Office of the President, (January 1972)

Petroleum Resources Under the Ocean Floor (Supplemental Report); National Petroleum Council (March 1971)

Programs & Resources; Environmental Research Laboratories, National Oceanic and Atmospheric Administration, Department of Commerce (June 1972)

Radioactivity in the Marine Environment, National Academy of Sciences (1972)

Remote Sensing of the Chesapeake Bay; National Aeronautics and Space Administration (SP-294) (April 1971)

Report on the National Shoreline Study; Corps of Engineers, Department of the Army (August 1971)

Sea Grant Newsletter Index, 1968-71; Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Data Service, NOAA Technical Memorandum EDS ESIC-6 (September 1972)

Sea Grant Publications Index, 1968-71, Volumes I & II; Environmental Data Service, National Oceanic and Atmospheric Administration, Department of Commerce (September 1972)

Summary Petroleum and Selected Mineral Statistics for 120 Countries, Including Offshore Areas; U.S. Geological Survey, Department of Interior (1973)

Toward Fulfillment of a National Ocean Commitment; National Academy of Engineering (1972)

Understanding the Mid-Atlantic Ridge: (A Comprehensive Program), National Academy of Sciences (January 1972)

University Curricula in the Marine Sciences and Related Fields, Academic Years 1973-1974, 1974-1975; Interagency Committee on Marine Science and Engineering, Federal Council for Science and Technology (1973) (Obtainable from Office of National Sea Grant Programs, National Oceanic and Atmospheric Administration)

* Available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Requests for others should be directed to issuing activity or publisher.

